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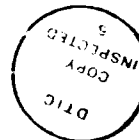


NRL Memorandum Report 6813

Modification of Programs CHIEF
and CID To Compute Sound Radiation
From An Arbitrary Body With
Mixed Boundary Conditions

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13. ABSTRACT (Maximum 200 words) The computer program CHIEF developed over the last two decades by Naval Ocean Systems Center, San Diego, has recently been modified to allow the computation of sound radiation from arbitrarily shaped body where the normal velocity is prescribed on only part of its surface while one or more locally reacting complex impedances are assumed to cover the remainder of the surface. These impedances can range in value from zero to essentially infinity with any complex value in between. Results of some computations of far-field directivity pattern and radiation loading on simple shaped radiators with the mixed boundary conditions were compared with results available in the literature with generally good agreement.				
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MODIFICATION OF PROGRAMS CHIEF AND CID TO COMPUTE SOUND RADIATION FROM AN ARBITRARY BODY WITH MIXED BOUNDARY CONDITIONS

INTRODUCTION

The computer program CHIEF [1], written to compute the sound radiation from an arbitrarily shaped body, was originally developed to handle only the case of Neumann boundary conditions on the surface of the body; i.e., the case where the normal velocity is prescribed over the entire surface.

There may be situations where it is desired to know the effect of putting some material on portions of the surface of the radiator. For example, it may be interesting to see if the shape or side-lobe structure of the directivity can be favorably changed or if such a material has a deleterious effect upon the radiation efficiency of the source. A case in point is that low-impedance material (pressure-release material) is often applied to the surface of an underwater structure to effect shielding of that part from the acoustic field.

From a mathematical point of view, this class of boundary value problems characterized by mixed boundary conditions [where at least two different types of boundary conditions (Neumann, Dirichlet, or Robin), also called impedance, are prescribed on the same surface] is not amenable to exact solution. Even for a simple coordinate surface such as a perfect sphere, the mix of boundary conditions means that the solution functions of the Helmholtz equation do not form a complete orthogonal basis set over the surface. Hence, the classic solution technique of expanding the boundary condition into a generalized Fourier Series and then matching mode for mode with a similar series expression for the radiation field is not applicable. Approximate matching procedures such as point collation and least-square error determination have been tried and are discussed in the literature. [2,3]

This report discusses modifications that have been made to the programs CHIEF and CID to accommodate the situation where part or parts of the radiator are covered with one or more locally reacting arbitrary complex impedance coatings. The range of magnitude of these impedances can be from zero (perfect pressure release) to the largest value the computer can handle without exponent overflow (rigid); any value that is purely real, purely imaginary or complex, in between these extremes is allowable. Three sample problems are presented to illustrate many of the new improvements to both CID and CHIEF.

NEW FEATURES AND MODIFICATIONS TO CHIEF

The following new features have been added to the 1991 version of CHIEF.

1. CHIEF now includes the capability to describe multiple locally reacting complex impedances.
2. The cone geometry has been added to CCUNMD.

3. The routine ZRADMI has been added to calculate the radiation matrix when impedance surfaces are defined.
4. New storage allocation (Units 26 through 29) have been assigned.

NEW FEATURES AND MODIFICATIONS TO CID

The following new features have been added to the 1991 version of CID.

1. The cone geometry has been added to the SURFACE DESCRIPTION screen (see Appendix B1).
2. The impedance surface description screens have been added (see Appendix B2).
3. The DISPLAY3D [4] program used to display the CHIEF geometries uses the CID screen input.

USER INPUTS AND SUBROUTINE CALLS

This section describes the changes that have been made to the input parameters and subroutine calls since the last program release.

General Input Parameters for Impedance Surfaces

- NUMZ Number of surface regions in a symmetry block that are covered with the impedance coating. (Note: The NUMZ impedance surfaces appear after the radiating surfaces.)
- ZCOAT Vector that contains the complex impedance coating for each surface region in a symmetry block.

Calculation of Radiation Matrix

ZRADMI(ZMTX, NUMARS)

- ZMTX Complex matrix area that must be allocated in control routine for storage of the radiation impedance matrix (NUMARS, NUMARS).
- NUMARS Number of surface areas (including impedance surfaces).

SAMPLE PROBLEMS

This section contains the CHIEF drivers for various types of sample problems. Since many of the dimension statements are the same for each control program, these lines will be printed only once and are labeled VARIABLE DECLARATION.

Common Variable Declaration

```

C ***** CONTROL 88 *****
C PROGRAM CHIEF88 DRIVER
C MXSREG - MAXIMUM NUMBER OF SURFACE REGIONS
C MXIPS - MAXIMUM NUMBER OF INTERIOR POINTS
C MXARS - MAXIMUM NUMBER OF SURFACE SUBDIVISIONS/SYM BLK
C MXGAUS - MAXIMUM ORDER OF GAUSSIAN QUADRATURE
C MXQPTS - MAXIMUM NUMBER OF QUADRATURE POINTS/SUBDIVISION
C MXBLKS - MAXIMUM NUMBER OF SYMMETRY BLOCKS
C MXFFP - MAXIMUM NUMBER OF FAR-FIELD POINTS
C MXNFP - MAXIMUM NUMBER OF NEAR-FIELD POINTS
C MXPTSC - MAXIMUM NUMBER OF POINT SOURCES
C MAXCOR - MAXIMUM NUMBER OF FINITE ELEMENT NODES
C MXFPS - MAX0(MXARS+MXIPS,MXFFP,MXNFP)

PARAMETER (MXSREG=500)
PARAMETER (MAXCOR=1000)
PARAMETER (MXIPS=20)
PARAMETER (MXARS=500)
PARAMETER (MXGAUS=64)
PARAMETER (MXQPTS=512)
PARAMETER (MXBLKS=100)
PARAMETER (MXFFP=301)
PARAMETER (MXNFP=301)
PARAMETER (MXPTSC=20)
PARAMETER (MXFPS=520)
C PARAMETER (MXFPS=MAX0(MXARS+MXIPS,MXFFP,MXNFP))
C PARAMETER (NWDVEC=2+MXARS)
C
C Input commons
C
COMMON /CONST/ RHO,C
COMMON /PRTCOM/ NUNPRT,NUNERR
COMMON /PRTD/ RUNID,DATE
CHARACTER*4 RUNID
CHARACTER*8 DATE
COMMON /N/A/G/ NDQPTS,NDPMXS,NDVMXS,NDDECM,NDVELS,NDSPS,
1 NDPMXF,NDVMXF,NDPMXN,NDVMXN,NDPSSP,NDEXPR,NDCOMV,
NDTEMP,NDZRD8,NDPATB
COMMON /SVALS/ NSREG,NSERMS(MXSREG),SUL(MXSREG),SUU(MXSREG),
1 SVL(MXSREG),SVU(MXSREG),NSU(MXSREG),NSV(MXSREG),
1 CCS(10,MXSREG),TRNSS(3,MXSREG),IZAX(MXSREG),
1 IORDU(MXSREG),IORDV(MXSREG),WCCEQS
COMMON /CORD/ COORDS(MAXCOR,3)
COMMON /IPTS/ NUMIPS,IPXS(3,MXIPS)
REAL IPXS
COMMON /PTSINP/ NUMPTS,PTSRC(4,MXPTSC),PTSWT(MXPTSC),
1 IOPTSC(MXPTSC)
COMPLEX PTSWT
COMMON /PLWINP/ AINC,THINC,PHINC,ISCATR
COMMON /BAFFLE/ INFBAF
COMMON /FFINP/ NUMTHP,THTPHI(2,MXFFP)
COMMON /NFINP/ NUMFPN,NFPXS(3,MXNFP)
REAL NFPXS
C
C Output commons
C
COMMON /TAPREC/ RECRD(10),IRECRD(30)
COMMON /TAPRC1/ ARECRD(10)
CHARACTER*4 ARECRD
COMMON /PRGVL/ NDIMPV,NUMARS,NUMSFP,NUMFFP,NUMNFP,NWDVEC
COMMON /SURARC/ AREAS(MXARS)
COMMON /ODSVEC/ TVECT(MXARS),B(MXARS),IPIVTR(MXFPS)
COMPLEX TVECT
COMMON /VELSPS/ VEL(MXARS),SP(MXARS)
COMPLEX VEL,SP
COMMON /PDISL/ POWER,DIRIND,SRCRYL
COMMON /FFVALS/ FFP(MXFFP),PNRMFF(MXFFP),IFFNRM,RMFFNRM
COMPLEX FFP
COMMON /TSCOM/ TGTSTH(MXFFP)
COMMON /NFVALS/ NFP(MXNFP),PNRMNF(MXNFP),INFNRM,RMNRM

```


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```

COMPLEX NFP
COMMON /PTSCOM/ PTSSP(MXARS)
COMPLEX PTSSP
COMMON /EXTCOM/ EXTPRS(MXFPS), IEXTFG
COMPLEX EXTPRS
COMMON /NBPRTC/ IRHSPT, NARSPT, NPTBLK, FRQPT
COMMON /NBPRTS/ SYMTPT
CHARACTER*3 SYMTPT

```

```

C***** impedance coating modifications *****
COMMON /COATING/ ZCOAT, NUMZ
COMPLEX ZCOAT(500)
C NUMZ - total number of impedance layer surfaces (NSU * NSV)
C*****

```

```

DIMENSION CC(10), TRNS(3), IELTS(8, 300)
REAL X1(1000), Y1(1000)

```

```

CHARACTER*3 SYMTYP
CHARACTER*4 FLDTYP, TAPEID, PRTTYP
INTEGER XIZAX, XNSEQNS, XIRG, XNSU, XNSV, XIORDU, XIORDV
INTEGER ICORR, IELEM

```

Sample Run 1: Radiating Polar Cap on an Impedance Coated Spherical Baffle

This sample problem computes the acoustic radiation from a spherical source consisting of a 90° uniformly vibrating polar cap while the rest of the sphere is covered with an impedance layer. Because of axisymmetry, the azimuthal coordinate angle was taken to be $1/30$ of the sphere. There are 24 regions; the first twelve regions (90°) define the polar cap. Thus, there are 12 regions with an impedance coated material.

Three cases were run using this break-up. In the first case, the impedance layer is defined as a perfect pressure-release material ($ZCOAT(I) = (0,0)$). In case 2, the impedance coating is defined as having ρc characteristics ($ZCOAT(I) = (\rho c, 0)$). And in case 3, the coating is defined as ($ZCOAT(I) = (10^{19}, 0)$), which simulates a rigid boundary condition. Setting $ZCOAT$ equal to 10^{19} (real or imaginary) produces far field results identical to those generated using the CHIEF where the velocity was specified to be identically zero on the impedance coated regions.

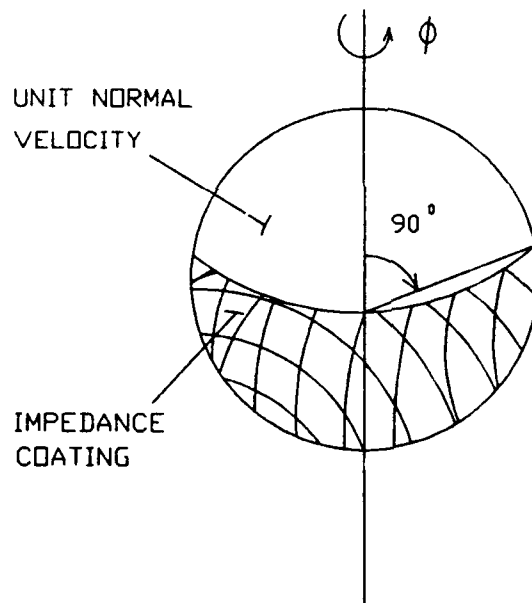
GEOMETRY OF THE PROBLEM

Fig. 1. 90° uniformly vibrating polar cap on an impedance-coated spherical baffle.

Program Listing of Sample Run 1

```

C   Program MRBILLT
C   SPHERE WITH IMPEDANCE COATING SURFACE
C   Variable Declarations
C   (COMMON VARIABLE DECLARATIONS GO HERE)

```

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```

COMPLEX PMATX( 1752), VMATX( 1752)
MDC, ZE = 1752
RUNID = 'MRBI'
DATE = '19-FEB-91'
CALL INITCM
CALL OPNSFL
RHO = 1000
C = 1500

OPEN(UNIT=NUNPRT, FILE=RUNID//'.OUT', STATUS='NEW'
1  FORM='FORMATTED')

```

```

C***** impedance coating modifications *****
NUMZ = 12
N = 1

```

```

C ----- load impedance for SPHERE
ZCOAT(N + 0) = CMPLX(0.0, 0.0)
ZCOAT(N + 1) = CMPLX(0.0, 0.0)
ZCOAT(N + 2) = CMPLX(0.0, 0.0)
ZCOAT(N + 3) = CMPLX(0.0, 0.0)
ZCOAT(N + 4) = CMPLX(0.0, 0.0)
ZCOAT(N + 5) = CMPLX(0.0, 0.0)
ZCOAT(N + 6) = CMPLX(0.0, 0.0)
ZCOAT(N + 7) = CMPLX(0.0, 0.0)
ZCOAT(N + 8) = CMPLX(0.0, 0.0)
ZCOAT(N + 9) = CMPLX(0.0, 0.0)
ZCOAT(N + 10) = CMPLX(0.0, 0.0)
ZCOAT(N + 11) = CMPLX(0.0, 0.0)
DO 99 JJ=1,3
N=1
IF (JJ.EQ. 1) THEN
ZCOAT(N + 12) = CMPLX(0.0, 0.0)
ZCOAT(N + 13) = CMPLX(0.0, 0.0)
ZCOAT(N + 14) = CMPLX(0.0, 0.0)
ZCOAT(N + 15) = CMPLX(0.0, 0.0)
ZCOAT(N + 16) = CMPLX(0.0, 0.0)
ZCOAT(N + 17) = CMPLX(0.0, 0.0)
ZCOAT(N + 18) = CMPLX(0.0, 0.0)
ZCOAT(N + 19) = CMPLX(0.0, 0.0)
ZCOAT(N + 20) = CMPLX(0.0, 0.0)
ZCOAT(N + 21) = CMPLX(0.0, 0.0)
ZCOAT(N + 22) = CMPLX(0.0, 0.0)
ZCOAT(N + 23) = CMPLX(0.0, 0.0)
END IF
IF (JJ.EQ. 2) THEN
ZCOAT(N + 12) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 13) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 14) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 15) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 16) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 17) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 18) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 19) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 20) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 21) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 22) = CMPLX(1.5E06, 0.0)
ZCOAT(N + 23) = CMPLX(1.5E06, 0.0)
END IF
IF (JJ.EQ. 3) THEN
ZCOAT(N + 12) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 13) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 14) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 15) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 16) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 17) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 18) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 19) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 20) = CMPLX(0.0, 1.0E19)
ZCOAT(N + 21) = CMPLX(0.0, 1.0E19)

```

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```
ZCOAT(N + 22) = CMPLX(0.0 , 1.0E19 )
ZCOAT(N + 23) = CMPLX(0.0 , 1.0E19 )
END IF
N = N + (24 * 1 )
```

C***** ***** end of impedance coating modifications *****

C symmetry inputs

```
PI = ACOS(-1.0)

SYMTYP = 'ROT'
NBLKS = 30
IRHSYM = 1
CONVERT = 1.0
```

C Surface Region inputs

```
ROTLIM = PI / NBLKS
XIRG = 0

DO 1 I = 1, 10
  CC(I) = 0.0
1 CONTINUE

DO 2 I = 1, 3
  TRNS(I) = 0.0
2 CONTINUE
```

C ----- SPHERE -----

```
XNSEQNS = 6
CC( 1) = 1. * CONVERT
CC( 2) = CC(1)*CC(1)
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = 0
XSUU = 3.14159265
XSVL = -0.10472
XSVU = 0.10472
XNSU = 24
XNSV = 1
XIORDU = 4
XIORDV = 04
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1 XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)

NSREG = XIRG
```

C CALL PLOTCHIEF(RUNID, NBLKS, SYMTYP, 1, 30.0, 60.0, 0.0)

C Define Frequency input.

```
FREQ = 718.20
```

C Generate surface P and V matrices.

```
CALL SURMAT(FREQ, SYMTYP, NBLKS, PMATX, VMATX, MDSIZE)
IF ( JJ.EQ. 1) THEN
  CALL PRTOU('GEOM',1)
  CALL PRTOU('AREA',1)
END IF
```

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C Decompose Matrices

```
CALL DECOMM(SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)
CALL IOSUB(NDVLS, 10, VEL, 0)
```

C Block # 1

```
VEL( 1) = (1.0000, 0.0000)
VEL( 2) = (1.0000, 0.0000)
VEL( 3) = (1.0000, 0.0000)
VEL( 4) = (1.0000, 0.0000)
VEL( 5) = (1.0000, 0.0000)
VEL( 6) = (1.0000, 0.0000)
VEL( 7) = (1.0000, 0.0000)
VEL( 8) = (1.0000, 0.0000)
VEL( 9) = (1.0000, 0.0000)
VEL(10) = (1.0000, 0.0000)
VEL(11) = (1.0000, 0.0000)
VEL(12) = (1.0000, 0.0000)
VEL(13) = (0.0000, 0.0000)
VEL(14) = (0.0000, 0.0000)
VEL(15) = (0.0000, 0.0000)
VEL(16) = (0.0000, 0.0000)
VEL(17) = (0.0000, 0.0000)
VEL(18) = (0.0000, 0.0000)
VEL(19) = (0.0000, 0.0000)
VEL(20) = (0.0000, 0.0000)
VEL(21) = (0.0000, 0.0000)
VEL(22) = (0.0000, 0.0000)
VEL(23) = (0.0000, 0.0000)
VEL(24) = (0.0000, 0.0000)
CALL IOSUB(NDVLS, 1, VEL, NWDVEC)
```

C Generate Surface Pressures.

```
CALL SURPRS(FREQ, SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

CALL PRTOUT('VEL',1)

CALL PRTOUT('SP',1)

FLDTYP = 'FAR '
NUMTHP = 73
DO 25 I = 1, NUMTHP
  THTPHI(1, I) = (I - 1) * 5
  THTPHI(2, I) = 0.0
```

25 CONTINUE

C Calculate FAR Field Matrices

```
CALL FLOWAT(FREQ, SYMTYP, FLDTYP, NBLKS, PMATX, VMATX, MDSIZE)

IFFNRW = 0
```

C Calculate Far-Field Pressures.

```
CALL FLDPRS(FREQ, FLDTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

CALL PRTOUT(FLDTYP, 1)
99 CONTINUE
STOP
END
```

The output listed below shows the input parameters for case 1. This is followed by the velocity distribution and surface pressures for all of the subdivisions. All of the symmetry strips are the same. Following the surface pressures is the normalized far-field patterns, and next are the surface pressures and patterns for cases 2 and 3.

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Output Listing of Sample Run 1

1

PROGRAM C H I E F 8 9 RUN MRBI DATE 19 FEB-9

REGION	NSEQNS	NSU	NSV	SUL	SUU	SVL	SVU	IORDRU	IORDRV
1	8	24	1	0.000000E+00	0.314159E+01	-1.04720E+00	0.104720E+00	4	4

REGION - TRANSLATION (T1,T2,T3),	IZAX
1 0.000000E+00 0.000000E+00 0.000000E+00	3

REGION - CCS

1	0.1000E+01	0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
---	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------

NO. OF SURFACE AREAS = 24 NO. OF SURFACE FIELD POINTS = 24

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

SURFACE AREAS (AREA#, AREA)

1	0.17918E-02
2	0.53447E-02
3	0.88062E-02
4	0.12117E-01
5	0.15220E-01
6	0.18063E-01
7	0.20597E-01
8	0.22779E-01
9	0.24571E-01
10	0.25942E-01
11	0.26870E-01
12	0.27337E-01
13	0.27337E-01
14	0.26870E-01
15	0.25942E-01
16	0.24571E-01
17	0.22779E-01
18	0.20597E-01
19	0.18063E-01
20	0.15220E-01
21	0.12117E-01
22	0.88062E-02
23	0.53447E-02
24	0.17913E-02

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 716.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

VELOCITIES (BLK#, AREA#, REAL, IMAG, MAG, ANG, REAL ZCOAT, IMAG ZCOAT)

BLK#	AREA#	REAL	IMAG	MAG	ANG	REAL ZCOAT	IMAG ZCOAT
1	1	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	2	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	3	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	4	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	5	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	6	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	7	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	8	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	9	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	10	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	11	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	12	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	13	-0.519161E+00	0.926700E+00	0.106134E+01	119.28	0.000000E+00	0.000000E+00
1	14	0.989358E+01	0.227281E+00	0.247090E+00	88.90	0.000000E+00	0.000000E+00
1	15	0.107755E+00	0.408740E+01	0.137204E+00	41.48	0.000000E+00	0.000000E+00
1	16	0.839903E+01	0.131100E+01	0.850073E+01	8.87	0.000000E+00	0.000000E+00

Thompson, Dubus, & Siders

1	17	0.528094E-01	-0.223428E-01	0.573414E-01	-22.93	0.000000E+00	0.000000E+00
1	18	0.240284E-01	-0.334544E-01	0.411894E-01	-54.31	0.000000E+00	0.000000E+00
1	19	0.255895E-02	-0.304915E-01	0.305987E-01	-85.20	0.000000E+00	0.000000E+00
1	20	-0.106377E-01	-0.206314E-01	0.232124E-01	-117.28	0.000000E+00	0.000000E+00
1	21	-0.168224E-01	-0.079903E-02	0.189847E-01	-152.39	0.000000E+00	0.000000E+00
1	22	-0.183030E-01	0.186566E-02	0.183978E-01	174.18	0.000000E+00	0.000000E+00
1	23	-0.175939E-01	0.961857E-02	0.200515E-01	151.33	0.000000E+00	0.000000E+00
1	24	-0.177578E-01	0.146317E-01	0.230093E-01	140.51	0.000000E+00	0.000000E+00

*** FULL VELOCITY SYMMETRY ***

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 710.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

SURFACE PRESSURES (BLK#, AREA#, REAL, IMAG, MAG, ANG)

1	1	0.130995E+07	0.243849E+05	0.131018E+07	1.07
1	2	0.134038E+07	0.755111E+05	0.134249E+07	3.22
1	3	0.139889E+07	0.142890E+06	0.140615E+07	5.82
1	4	0.147041E+07	0.235899E+06	0.148018E+07	9.11
1	5	0.153852E+07	0.354132E+06	0.157681E+07	12.98
1	6	0.157708E+07	0.491621E+06	0.165188E+07	17.31
1	7	0.167324E+07	0.636299E+06	0.169705E+07	22.02
1	8	0.150995E+07	0.771650E+06	0.169586E+07	27.07
1	9	0.137795E+07	0.875019E+06	0.163230E+07	32.42
1	10	0.117443E+07	0.918871E+06	0.149105E+07	38.03
1	11	0.099727E+06	0.864173E+06	0.124752E+07	43.85
1	12	0.537282E+06	0.631044E+06	0.828787E+06	49.59
1	13	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	14	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	15	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	16	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	17	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	18	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	19	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	20	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	21	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	22	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	23	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1	24	0.000000E+00	0.000000E+00	0.000000E+00	0.00

*** FULL VELOCITY SYMMETRY ***

POWER OUT(KW)= 7846.250

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 710.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

FAR-FIELD PRESSURES (PHI, THETA, FFP(RL, IM, MAG, ANG) , NORMALIZED PATTERN, SOURCE LEVEL, DI)

0.00	0.00	-0.260523E+07	-0.655189E+06	0.258949E+07	-185.34	0.00	*	248.3	8.52
0.00	5.00	-0.248029E+07	-0.658300E+06	0.258565E+07	-185.18	-0.08			
0.00	10.00	-0.240739E+07	-0.659422E+06	0.249607E+07	-184.68	-0.32			
0.00	15.00	-0.229205E+07	-0.663957E+06	0.238028E+07	-183.84	-0.71			
0.00	20.00	-0.214270E+07	-0.668968E+06	0.224470E+07	-182.66	-1.24			
0.00	25.00	-0.196964E+07	-0.673270E+06	0.208153E+07	-181.13	-1.90			
0.00	30.00	-0.178384E+07	-0.675539E+06	0.190747E+07	-159.28	-2.66			
0.00	35.00	-0.159587E+07	-0.674413E+06	0.173252E+07	-157.09	-3.49			
0.00	40.00	-0.141487E+07	-0.668600E+06	0.156489E+07	-154.71	-4.37			
0.00	45.00	-0.124797E+07	-0.660603E+06	0.141033E+07	-152.24	-5.28			
0.00	50.00	-0.109996E+07	-0.638582E+06	0.127188E+07	-149.86	-6.18			
0.00	55.00	-0.973268E+06	-0.612810E+06	0.115012E+07	-147.80	-7.05			
0.00	60.00	-0.868210E+06	-0.579294E+06	0.104373E+07	-146.29	-7.89			
0.00	65.00	-0.783448E+06	-0.537995E+06	0.950383E+06	-145.52	-8.71			
0.00	70.00	-0.716384E+06	-0.489182E+06	0.867471E+06	-145.07	-9.50			

NRL MEMORANDUM REPORT 6813

0.00	75.00	- .86368E+06	- .433439E+06	0.792684E+06	-148.85	-10.28
0.00	80.00	- .821697E+06	- .371842E+06	0.724310E+06	-149.13	-11.07
0.00	85.00	- .586782E+06	- .304956E+06	0.661296E+06	-152.54	-11.86
0.00	90.00	- .555574E+06	- .234820E+06	0.603161E+06	-157.09	-12.66
0.00	95.00	- .525139E+06	- .162931E+06	0.549834E+06	-162.76	-13.46
0.00	100.00	- .493061E+06	- .912237E+05	0.501429E+06	-169.52	-14.26
0.00	105.00	- .457477E+06	- .218402E+05	0.457998E+06	-177.27	-15.05
0.00	110.00	- .417065E+06	0.429270E+05	0.419268E+06	174.12	-15.81
0.00	115.00	- .371019E+06	0.100720E+06	0.384448E+06	164.81	-16.57
0.00	120.00	- .319018E+06	0.149247E+06	0.352203E+06	154.93	-17.33
0.00	125.00	- .261194E+06	0.188452E+06	0.320516E+06	144.48	-18.14
0.00	130.00	- .198128E+06	0.210736E+06	0.289248E+06	133.23	-19.04
0.00	135.00	- .130837E+06	0.221192E+06	0.256991E+06	120.60	-20.07
0.00	140.00	- .607839E+05	0.217836E+06	0.226158E+06	105.59	-21.18
0.00	145.00	0.101391E+05	0.201777E+06	0.202031E+06	87.12	-22.16
0.00	150.00	0.796466E+05	0.175286E+06	0.192532E+06	65.56	-22.57
0.00	155.00	0.145143E+06	0.141716E+06	0.202854E+06	44.32	-22.12
0.00	160.00	0.203864E+06	0.105242E+06	0.229426E+06	27.30	-21.05
0.00	165.00	0.253066E+06	0.704420E+05	0.262687E+06	15.55	-19.88
0.00	170.00	0.290257E+06	0.417507E+05	0.293245E+06	8.19	-18.92
0.00	175.00	0.313440E+06	0.228810E+05	0.314274E+06	4.18	-18.32
0.00	180.00	0.321317E+06	0.163023E+05	0.321731E+06	2.90	-18.11
0.00	185.00	0.313440E+05	0.228810E+05	0.314274E+05	4.18	-18.32
0.00	190.00	0.290257E+06	0.417508E+05	0.293245E+06	8.19	-18.92
0.00	195.00	0.253066E+06	0.704419E+05	0.262687E+06	15.55	-19.88
0.00	200.00	0.203864E+06	0.105242E+06	0.229427E+06	27.30	-21.05
0.00	205.00	0.145143E+06	0.141716E+06	0.202854E+06	44.32	-22.12
0.00	210.00	0.796466E+05	0.175286E+06	0.192532E+06	65.56	-22.57
0.00	215.00	0.101392E+05	0.201777E+06	0.202031E+06	87.12	-22.16
0.00	220.00	- .607837E+05	0.217836E+06	0.226157E+06	105.59	-21.18
0.00	225.00	- .130837E+06	0.221192E+06	0.256991E+06	120.60	-20.07
0.00	230.00	- .198128E+06	0.210736E+06	0.289248E+06	133.23	-19.04
0.00	235.00	- .261194E+06	0.188452E+06	0.320915E+06	144.48	-18.14
0.00	240.00	- .319018E+06	0.149247E+06	0.352203E+06	154.93	-17.33
0.00	245.00	- .371019E+06	0.100720E+06	0.384448E+06	164.81	-16.57
0.00	250.00	- .417065E+06	0.429269E+05	0.419268E+06	174.12	-15.81
0.00	255.00	- .457477E+06	- .218403E+05	0.457998E+06	-177.27	-15.05
0.00	260.00	- .493061E+06	- .912238E+05	0.501429E+06	-169.52	-14.26
0.00	265.00	- .525139E+06	- .162931E+06	0.549834E+06	-162.76	-13.46
0.00	270.00	- .555574E+06	- .234820E+06	0.603161E+06	-157.09	-12.66
0.00	275.00	- .586782E+06	- .304956E+06	0.661295E+06	-152.54	-11.86
0.00	280.00	- .621697E+06	- .371842E+06	0.724310E+06	-149.13	-11.07
0.00	285.00	- .663688E+06	- .433439E+06	0.792684E+06	-148.85	-10.28
0.00	290.00	- .716384E+06	- .489182E+06	0.867470E+06	-145.67	-9.50
0.00	295.00	- .783448E+06	- .537994E+06	0.950383E+06	-145.52	-8.71
0.00	300.00	- .868210E+06	- .579294E+06	0.104373E+07	-146.29	-7.89
0.00	305.00	- .973258E+06	- .612810E+06	0.115012E+07	-147.80	-7.05
0.00	310.00	- .109998E+07	- .638582E+06	0.127188E+07	-149.88	-6.18
0.00	315.00	- .124797E+07	- .656962E+06	0.141033E+07	-152.24	-5.28
0.00	320.00	- .141487E+07	- .688600E+06	0.156489E+07	-154.71	-4.37
0.00	325.00	- .159587E+07	- .674413E+06	0.173252E+07	-157.09	-3.49
0.00	330.00	- .178384E+07	- .675539E+06	0.190747E+07	-159.26	-2.66
0.00	335.00	- .196964E+07	- .673270E+06	0.208153E+07	-161.13	-1.90
0.00	340.00	- .214270E+07	- .680958E+06	0.224470E+07	-162.66	-1.24
0.00	345.00	- .229205E+07	- .683957E+06	0.238628E+07	-163.84	-0.71
0.00	350.00	- .240739E+07	- .659422E+06	0.249607E+07	-164.68	-0.32
0.00	355.00	- .248029E+07	- .656299E+06	0.256565E+07	-165.18	-0.00
0.00	360.00	- .250523E+07	- .655189E+06	0.258949E+07	-165.34	0.00

* DIRECTION FOR PATTERN NORMALIZATION

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 716.2 RHO= 1000 0 C= 1600 0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

VELOCITIES (BLK#,AREA#, REAL,IMAG,MAG,ANG, REAL ZCOAT, IMAG ZCOAT)

Thompson, Dubus, & Siders

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1 1 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 2 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 3 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 4 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 5 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 6 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 7 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 8 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 9 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 10 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 11 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 12 0.100000E+01 0.000000E+00 0.100000E+01 0.00 0.000000E+00 0.000000E+00
1 13 -0.200403E+00 0.733950E-01 0.295650E+00 165.63 0.150000E+07 0.000000E+00
1 14 -0.112223E+00 0.163832E+00 0.198582E+00 124.41 0.150000E+07 0.000000E+00
1 15 0.411214E-02 0.145290E+00 0.145340E+00 88.38 0.150000E+07 0.000000E+00
1 16 0.860318E-01 0.926511E-01 0.113092E+00 54.49 0.150000E+07 0.000000E+00
1 17 0.865737E-01 0.366450E-01 0.930901E-01 23.18 0.150000E+07 0.000000E+00
1 18 0.758692E-01 -0.752730E-02 0.782417E-01 -5.67 0.150000E+07 0.000000E+00
1 19 0.490632E-01 -0.342943E-01 0.698006E-01 -34.95 0.150000E+07 0.000000E+00
1 20 0.162133E-01 -0.440110E-01 0.466663E-01 -70.93 0.150000E+07 0.000000E+00
1 21 -0.181976E-01 -0.408060E-01 0.446003E-01 -114.03 0.150000E+07 0.000000E+00
1 22 -0.462319E-01 -0.306854E-01 0.554885E-01 -146.43 0.150000E+07 0.000000E+00
1 23 -0.800933E-01 -0.199423E-01 0.690384E-01 -163.21 0.150000E+07 0.000000E+00
1 24 -0.764700E-01 -0.141181E-01 0.777623E-01 -169.54 0.150000E+07 0.000000E+00

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*** FULL VELOCITY SYMMETRY ***

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 716.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

SURFACE PRESSURES (BLK#, AREA#, REAL, IMAG, MAG, ANG)

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1 1 0.135219E+07 0.100000E+00 0.135639E+07 4.51
1 2 0.137523E+07 0.163807E+00 0.138150E+07 6.38
1 3 0.141384E+07 0.212236E+00 0.142968E+07 8.54
1 4 0.146273E+07 0.291468E+00 0.149149E+07 11.27
1 5 0.150621E+07 0.390219E+00 0.155497E+07 14.53
1 6 0.152670E+07 0.501918E+00 0.160620E+07 18.21
1 7 0.151036E+07 0.615851E+00 0.163109E+07 22.18
1 8 0.144821E+07 0.717894E+00 0.161603E+07 26.34
1 9 0.133376E+07 0.788504E+00 0.154839E+07 30.53
1 10 0.116770E+07 0.800058E+00 0.141649E+07 34.42
1 11 0.956601E+06 0.724315E+00 0.119988E+07 37.13
1 12 0.709710E+06 0.407582E+00 0.861000E+06 34.49
1 13 0.429006E+06 -0.110094E+00 0.443487E+06 -14.37
1 14 0.168335E+06 -0.245748E+00 0.297874E+06 -55.59
1 15 -0.616821E+04 -0.217935E+00 0.218023E+06 -91.62
1 16 -0.990477E+05 -0.138827E+00 0.170538E+06 -125.51
1 17 -0.128361E+06 -0.549084E+05 0.139635E+06 -150.82
1 18 -0.113804E+06 0.112911E+05 0.114363E+06 174.33
1 19 -0.735947E+05 0.514414E+05 0.897909E+05 145.05
1 20 -0.228199E+05 0.660166E+05 0.698494E+05 109.07
1 21 0.272963E+05 0.612099E+05 0.670204E+05 65.97
1 22 0.693478E+05 0.460280E+05 0.832328E+05 33.57
1 23 0.991400E+05 0.299134E+05 0.103656E+06 16.79
1 24 0.114705E+06 0.211771E+05 0.116643E+06 10.46

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*** FULL VELOCITY SYMMETRY ***

POWER OUT(KW)= 7883.426

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 716.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

FAR-FIELD PRESSURES (PHI, THETA, FFP(RL, IM, MAG, ANG) , NORMALIZED PATTERN, SOURCE LEVEL, DI)

NRL MEMORANDUM REPORT 6813

0.00	0.00	-225230E+07	-339591E+06	0.234135E+07	-184.16	0.00 *	247.4	7.75
0.00	5.00	-223294E+07	-339514E+06	0.232271E+07	-184.02	-0.07		
0.00	10.00	-217827E+07	-339204E+06	0.228820E+07	-183.63	-0.28		
0.00	15.00	-208835E+07	-338426E+06	0.218184E+07	-182.99	-0.61		
0.00	20.00	-196939E+07	-336783E+06	0.208978E+07	-182.08	-1.07		
0.00	25.00	-183302E+07	-333738E+06	0.193948E+07	-180.93	-1.64		
0.00	30.00	-168544E+07	-328609E+06	0.179885E+07	-159.55	-2.29		
0.00	35.00	-153480E+07	-320606E+06	0.165534E+07	-157.98	-3.01		
0.00	40.00	-138751E+07	-308855E+06	0.151522E+07	-156.31	-3.78		
0.00	45.00	-124974E+07	-592457E+06	0.138306E+07	-154.64	-4.57		
0.00	50.00	-112521E+07	-570537E+06	0.126159E+07	-153.11	-5.37		
0.00	55.00	-101814E+07	-542312E+06	0.115180E+07	-151.91	-6.16		
0.00	60.00	-923238E+06	-507165E+06	0.105337E+07	-151.22	-6.94		
0.00	65.00	-845913E+06	-484707E+06	0.985154E+06	-151.22	-7.70		
0.00	70.00	-782670E+06	-414851E+06	0.885818E+06	-152.07	-8.44		
0.00	75.00	-731383E+06	-357862E+06	0.814239E+06	-153.93	-9.17		
0.00	80.00	-689582E+06	-294408E+06	0.749800E+06	-156.88	-9.89		
0.00	85.00	-654681E+06	-225586E+06	0.692438E+06	-160.99	-10.58		
0.00	90.00	-623999E+06	-152931E+06	0.642487E+06	-166.23	-11.23		
0.00	95.00	-595031E+06	-783976E+05	0.600173E+06	-172.49	-11.82		
0.00	100.00	-565256E+06	-430427E+04	0.565273E+06	-179.58	-12.34		
0.00	105.00	-532241E+06	0.667534E+05	0.536411E+06	172.85	-12.80		
0.00	110.00	-493619E+06	0.132036E+06	0.510973E+06	165.02	-13.22		
0.00	115.00	-447141E+06	0.188833E+06	0.485379E+06	157.11	-13.67		
0.00	120.00	-390785E+06	0.234809E+06	0.455832E+06	149.01	-14.21		
0.00	125.00	-322938E+06	0.287532E+06	0.419360E+06	140.36	-14.94		
0.00	130.00	-242650E+06	0.286109E+06	0.375150E+06	130.30	-15.91		
0.00	135.00	-149922E+06	0.289987E+06	0.326449E+06	117.34	-17.11		
0.00	140.00	-459879E+05	0.279807E+06	0.283561E+06	99.33	-18.34		
0.00	145.00	0.684792E+05	0.257322E+06	0.265770E+06	75.51	-18.90		
0.00	150.00	0.183306E+06	0.225345E+06	0.290485E+06	50.87	-18.13		
0.00	155.00	0.298966E+06	0.137567E+06	0.352933E+06	32.10	-16.44		
0.00	160.00	0.406947E+06	0.146245E+06	0.433108E+06	20.02	-14.68		
0.00	165.00	0.500352E+06	0.111798E+06	0.512690E+06	12.60	-13.19		
0.00	170.00	0.572635E+06	0.823355E+05	0.578524E+06	8.18	-12.14		
0.00	175.00	0.618392E+06	0.631948E+05	0.621613E+06	5.83	-11.52		
0.00	180.00	0.634060E+06	0.585625E+05	0.636578E+06	5.10	-11.31		
0.00	185.00	0.61392E+06	0.631947E+05	0.621613E+06	5.83	-11.52		
0.00	190.00	0.572635E+06	0.823334E+05	0.578523E+06	8.18	-12.14		
0.00	195.00	0.500352E+06	0.111797E+06	0.512690E+06	12.60	-13.19		
0.00	200.00	0.406948E+06	0.148245E+06	0.433108E+06	20.02	-14.68		
0.00	205.00	0.298966E+06	0.187568E+06	0.352933E+06	32.10	-16.44		
0.00	210.00	0.183307E+06	0.225345E+06	0.290485E+06	50.87	-18.13		
0.00	215.00	0.684793E+05	0.257321E+06	0.265770E+06	75.51	-18.90		
0.00	220.00	-459875E+05	0.279807E+06	0.283561E+06	99.33	-18.34		
0.00	225.00	-149921E+06	0.289987E+06	0.326449E+06	117.34	-17.11		
0.00	230.00	-242650E+06	0.286109E+06	0.375150E+06	130.30	-15.91		
0.00	235.00	-322938E+06	0.287532E+06	0.419360E+06	140.36	-14.94		
0.00	240.00	-390785E+06	0.234809E+06	0.455831E+06	149.01	-14.21		
0.00	245.00	-447141E+06	0.188833E+06	0.485379E+06	157.11	-13.67		
0.00	250.00	-493619E+06	0.132036E+06	0.510973E+06	165.02	-13.22		
0.00	255.00	-532241E+06	0.667533E+05	0.536411E+06	172.85	-12.80		
0.00	260.00	-565256E+06	-430442E+04	0.565273E+06	-179.58	-12.34		
0.00	265.00	-595031E+06	-783976E+05	0.600173E+06	-172.49	-11.82		
0.00	270.00	-623999E+06	-152931E+06	0.642486E+06	-166.23	-11.23		
0.00	275.00	-654681E+06	-225586E+06	0.692438E+06	-160.99	-10.58		
0.00	280.00	-689582E+06	-294408E+06	0.749800E+06	-156.88	-9.89		
0.00	285.00	-731382E+06	-357862E+06	0.814239E+06	-153.93	-9.17		
0.00	290.00	-782670E+06	-414850E+06	0.885818E+06	-152.07	-8.44		
0.00	295.00	-845913E+06	-484707E+06	0.985153E+06	-151.22	-7.70		
0.00	300.00	-923238E+06	-507164E+06	0.105337E+07	-151.22	-6.94		
0.00	305.00	-101814E+07	-542312E+06	0.115180E+07	-151.91	-6.16		
0.00	310.00	-112521E+07	-570536E+06	0.126159E+07	-153.11	-5.37		
0.00	315.00	-124974E+07	-592457E+06	0.138306E+07	-154.64	-4.57		
0.00	320.00	-138751E+07	-608855E+06	0.151522E+07	-156.31	-3.78		
0.00	325.00	-153480E+07	-620605E+06	0.165534E+07	-157.98	-3.01		
0.00	330.00	-168544E+07	-628609E+06	0.179885E+07	-159.55	-2.29		
0.00	335.00	-183302E+07	-633738E+06	0.193948E+07	-160.93	-1.64		
0.00	340.00	-196939E+07	-636783E+06	0.208978E+07	-162.08	-1.07		
0.00	345.00	-208834E+07	-638426E+06	0.218184E+07	-162.99	-0.61		
0.00	350.00	-217827E+07	-639204E+06	0.228820E+07	-163.63	-0.28		

Thompson, Dubus, & Siders

0.00 355.00 - .223294E+07 - .039514E+06 0.232271E+07 -164.02 -0.07
0.00 360.00 - .226230E+07 - .039591E+06 0.234135E+07 -164.15 0.00

* DIRECTION FOR PATTERN NORMALIZATION

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY: 716.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

VELOCITIES (BLK#,AREA#, REAL,IMAG,MAG,ANG, REAL ZCOAT, IMAG ZCOAT)

1	1	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	2	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	3	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	4	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	5	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	6	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	7	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	8	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	9	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	10	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	11	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	12	0.100000E+01	0.000000E+00	0.100000E+01	0.00	0.000000E+00	0.000000E+00
1	13	0.329050E-14	0.568012E-13	0.568008E-13	86.67	0.000000E+00	0.100000E+20
1	14	0.243183E-13	0.353465E-13	0.429028E-13	55.47	0.000000E+00	0.100000E+20
1	15	0.312218E-13	0.160352E-13	0.353789E-13	28.05	0.000000E+00	0.100000E+20
1	16	0.300086E-13	0.175188E-14	0.301195E-13	3.33	0.000000E+00	0.100000E+20
1	17	0.238301E-13	-0.855009E-14	0.253197E-13	-19.75	0.000000E+00	0.100000E+20
1	18	0.146886E-13	-0.141828E-13	0.204044E-13	-43.96	0.000000E+00	0.100000E+20
1	19	0.439377E-14	-0.156414E-13	0.161506E-13	-74.21	0.000000E+00	0.100000E+20
1	20	-0.569057E-14	-0.136599E-13	0.147978E-13	-112.62	0.000000E+00	0.100000E+20
1	21	-0.145778E-13	-0.979933E-14	0.175653E-13	-146.09	0.000000E+00	0.100000E+20
1	22	-0.216270E-13	-0.534355E-14	0.222774E-13	-166.12	0.000000E+00	0.100000E+20
1	23	-0.264009E-13	-0.155915E-14	0.265277E-13	-178.83	0.000000E+00	0.100000E+20
1	24	-0.289044E-13	0.594412E-15	0.290045E-13	178.83	0.000000E+00	0.100000E+20

*** FULL VELOCITY SYMMETRY ***

1

PROGRAM C H I E F 8 8 RUN MRBI DATE 19-FEB-9

FREQUENCY= 716.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

SURFACE PRESSURES (BLK#,AREA#, REAL,IMAG,MAG,ANG)

1	1	0.135092E+07	0.137472E+06	0.135790E+07	5.81
1	2	0.136950E+07	0.181612E+06	0.138149E+07	7.55
1	3	0.140664E+07	0.234871E+06	0.142611E+07	9.48
1	4	0.145111E+07	0.306363E+06	0.148310E+07	11.92
1	5	0.148982E+07	0.395438E+06	0.154141E+07	14.86
1	6	0.150808E+07	0.490214E+06	0.158819E+07	18.21
1	7	0.149497E+07	0.598979E+06	0.161050E+07	21.83
1	8	0.143898E+07	0.690126E+06	0.159591E+07	25.62
1	9	0.133593E+07	0.752193E+06	0.153313E+07	29.38
1	10	0.118709E+07	0.763406E+06	0.141137E+07	32.74
1	11	0.999900E+06	0.894102E+06	0.121727E+07	34.77
1	12	0.787448E+06	0.483704E+06	0.924144E+06	31.58
1	13	0.568012E+06	-0.329050E+05	0.568008E+06	-3.33
1	14	0.353465E+06	-0.243183E+06	0.429028E+06	-34.53
1	15	0.160352E+06	-0.312218E+06	0.353789E+06	-61.95
1	16	0.175188E+06	-0.300086E+06	0.301195E+06	-86.67
1	17	-0.855009E+05	-0.238301E+06	0.253197E+06	-109.75
1	18	-0.141828E+06	-0.146886E+06	0.204044E+06	-133.96
1	19	-0.156414E+06	-0.439377E+05	0.161506E+06	-164.21
1	20	-0.136599E+06	0.569057E+05	0.147978E+06	157.38
1	21	-0.979933E+05	0.145778E+06	0.175653E+06	123.91
1	22	-0.534355E+05	0.216270E+06	0.222774E+06	103.88
1	23	-0.155915E+05	0.264009E+06	0.265277E+06	93.37

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1 24 0.594412E+04 0.299384E+06 0.290245E+06 88.83
 *** FULL VELOCITY SYMMETRY ***

POWER OUT(KW)= 7958 770

1

PROGRAM C H I E F S 3 RUN MPBI DATE 19-FEB-9

FREQUENCY= 710.2 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 30

FAR-FIELD PRESSURES (PHI, THETA, FFP(RI, IM, MAG, ANG) , NORMALIZED PATTERN, SOURCE LEVEL, DI)

0.00	0.00	- 218313E+07	- 800880E+06	0.228426E+07	-184.82	0.00
0.00	5.00	- 216523E+07	- 801108E+06	0.224712E+07	-184.48	-0.07
0.00	10.00	- 211282E+07	- 802237E+06	0.219698E+07	-184.09	-0.28
0.00	15.00	- 202958E+07	- 803609E+06	0.211743E+07	-183.44	-0.58
0.00	20.00	- 192112E+07	- 804498E+06	0.201390E+07	-182.53	-1.02
0.00	25.00	- 179443E+07	- 803972E+06	0.189335E+07	-181.40	-1.55
0.00	30.00	- 165784E+07	- 802353E+06	0.176285E+07	-180.07	-2.18
0.00	35.00	- 151637E+07	- 594323E+06	0.162888E+07	-158.60	-2.86
0.00	40.00	- 137904E+07	- 582973E+06	0.149720E+07	-157.08	-3.59
0.00	45.00	- 125048E+07	- 565931E+06	0.137258E+07	-155.65	-4.36
0.00	50.00	- 113462E+07	- 542414E+06	0.125781E+07	-154.46	-5.11
0.00	55.00	- 103388E+07	- 511910E+06	0.115387E+07	-153.66	-5.88
0.00	60.00	- 949194E+06	- 474217E+06	0.108106E+07	-153.46	-6.58
0.00	65.00	- 880240E+06	- 429479E+06	0.979428E+06	-153.99	-7.28
0.00	70.00	- 826874E+06	- 378190E+06	0.908186E+06	-155.39	-7.94
0.00	75.00	- 783375E+06	- 321181E+06	0.846661E+06	-157.71	-8.54
0.00	80.00	- 750675E+06	- 259583E+06	0.794290E+06	-160.92	-9.10
0.00	85.00	- 724548E+06	- 194771E+06	0.750280E+06	-164.95	-9.59
0.00	90.00	- 701752E+06	- 128293E+06	0.713383E+06	-189.84	-10.03
0.00	95.00	- 678982E+06	- 617906E+06	0.681767E+06	-174.80	-10.43
0.00	100.00	- 652840E+06	0.309078E+04	0.652847E+06	179.73	-10.80
0.00	105.00	- 620150E+06	0.647910E+05	0.623525E+06	174.84	-11.20
0.00	110.00	- 577883E+06	0.121919E+06	0.590585E+06	168.09	-11.67
0.00	115.00	- 512089E+06	0.173327E+06	0.551266E+06	161.87	-12.27
0.00	120.00	- 454384E+06	0.218166E+06	0.504027E+06	154.35	-13.06
0.00	125.00	- 369081E+06	0.255928E+06	0.449626E+06	145.31	-14.04
0.00	130.00	- 268939E+06	0.288480E+06	0.392922E+06	133.19	-15.21
0.00	135.00	- 153082E+06	0.309961E+06	0.345702E+06	116.28	-16.32
0.00	140.00	- 245133E+05	0.326947E+06	0.327885E+06	94.29	-16.78
0.00	145.00	0.112824E+06	0.338207E+06	0.358529E+06	71.55	-16.86
0.00	150.00	0.253512E+06	0.344729E+06	0.427909E+06	53.67	-14.47
0.00	155.00	0.390911E+06	0.347622E+06	0.523118E+06	41.65	-12.73
0.00	160.00	0.517817E+06	0.348028E+06	0.623740E+06	33.92	-11.20
0.00	165.00	0.626880E+06	0.347032E+06	0.715826E+06	29.00	-10.00
0.00	170.00	0.709337E+06	0.345578E+06	0.789039E+06	25.97	-9.16
0.00	175.00	0.761749E+06	0.344396E+06	0.835985E+06	24.33	-8.65
0.00	180.00	0.779848E+06	0.343950E+06	0.852144E+06	23.81	-8.49
0.00	185.00	0.761749E+06	0.344397E+06	0.835985E+06	24.33	-8.65
0.00	190.00	0.709337E+06	0.345578E+06	0.789039E+06	25.97	-9.16
0.00	195.00	0.626880E+06	0.347032E+06	0.715826E+06	29.00	-10.00
0.00	200.00	0.517817E+06	0.348028E+06	0.623740E+06	33.92	-11.20
0.00	205.00	0.390912E+06	0.347622E+06	0.523118E+06	41.65	-12.73
0.00	210.00	0.253512E+06	0.344729E+06	0.427909E+06	53.67	-14.47
0.00	215.00	0.112826E+06	0.338207E+06	0.358529E+06	71.55	-16.86
0.00	220.00	- 245130E+05	0.326947E+06	0.327885E+06	94.29	-16.78
0.00	225.00	- 153082E+06	0.309961E+06	0.345702E+06	116.28	-16.32
0.00	230.00	- 268939E+06	0.288480E+06	0.392922E+06	133.19	-15.21
0.00	235.00	- 369081E+06	0.255928E+06	0.449626E+06	145.31	-14.04
0.00	240.00	- 454384E+06	0.218166E+06	0.504027E+06	154.35	-13.06
0.00	245.00	- 523309E+06	0.173327E+06	0.551266E+06	161.87	-12.27
0.00	250.00	- 577883E+06	0.121919E+06	0.590585E+06	168.09	-11.67
0.00	255.00	- 620150E+06	0.647910E+05	0.623525E+06	174.84	-11.20
0.00	260.00	- 652840E+06	0.309063E+04	0.652847E+06	179.73	-10.80
0.00	265.00	- 678981E+06	- 617906E+06	0.681767E+06	-174.80	-10.43
0.00	270.00	- 701762E+06	- 128292E+06	0.713383E+06	-189.84	-10.03
0.00	275.00	- 724548E+06	- 194770E+06	0.750268E+06	-164.95	-9.59
0.00	280.00	- 750674E+06	- 259583E+06	0.794289E+06	-160.92	-9.10

Thompson, Dubus, & Siders

0.00	285.00	-.783375E+06	-.321181E+06	0.848680E+06	-157.71	-8.54
0.00	290.00	-.825674E+06	-.378190E+06	0.908168E+06	-155.39	-7.94
0.00	295.00	-.880240E+06	-.429478E+06	0.979425E+06	-153.99	-7.28
0.00	300.00	-.949194E+06	-.474216E+06	0.106108E+07	-153.45	-6.58
0.00	305.00	-.103388E+07	-.511910E+06	0.116387E+07	-153.68	-5.88
0.00	310.00	-.113482E+07	-.542414E+06	0.125781E+07	-154.45	-5.11
0.00	315.00	-.125048E+07	-.565930E+06	0.137256E+07	-155.65	-4.35
0.00	320.00	-.137904E+07	-.582973E+06	0.149720E+07	-157.08	-3.59
0.00	325.00	-.151637E+07	-.594322E+06	0.162868E+07	-158.80	-2.86
0.00	330.00	-.165704E+07	-.600958E+06	0.176265E+07	-160.07	-2.18
0.00	335.00	-.179443E+07	-.603972E+06	0.189334E+07	-161.40	-1.55
0.00	340.00	-.192112E+07	-.604498E+06	0.201398E+07	-162.53	-1.02
0.00	345.00	-.202958E+07	-.603608E+06	0.211743E+07	-163.44	-0.58
0.00	350.00	-.211282E+07	-.602237E+06	0.219898E+07	-164.09	-0.26
0.00	355.00	-.218523E+07	-.601108E+06	0.224712E+07	-164.48	-0.07
0.00	360.00	-.218313E+07	-.600680E+06	0.228426E+07	-164.62	0.00 * 247.1 7.29

* DIRECTION FOR PATTERN NORMALIZATION

The agreement between the far-field directivity pattern computed by the technique described by Butler [2] and the modified CHIEF program is so close that no difference would be discerned from a plot of two sets of data. Hence, the data is listed in tabular form in Table 1.

Table 1 - Directivity Patterns For Three Different Impedance Values.

Bearing Angle	Surface $Z = 0.0$		Surface $Z = \rho c$		Surface $Z = \text{RIGID}$	
	Ref. (2)	Modified CHIEF	Ref. (2)	Modified CHIEF	Ref. (2)	Modified CHIEF
0°	0.0 dB	0.0 dB	0.0 dB	0.0 dB	0.0 dB	0.0 dB
10°	-0.4 dB	-0.3 dB	-0.3 dB	-0.3 dB	-0.3 dB	-0.3 dB
20°	-1.2 dB	-1.2 dB	-1.1 dB	-1.1 dB	-1.1 dB	-1.0 dB
30°	-2.6 dB	-2.7 dB	-2.2 dB	-2.3 dB	-2.2 dB	-2.2 dB
40°	-4.4 dB	-4.4 dB	-3.6 dB	-3.8 dB	-3.8 dB	-3.6 dB
50°	-6.1 dB	-6.2 dB	-5.2 dB	-5.4 dB	-5.1 dB	-5.1 dB
60°	-7.7 dB	-7.9 dB	-6.9 dB	-6.9 dB	-6.7 dB	-6.6 dB
70°	-9.1 dB	-9.5 dB	-8.3 dB	-8.4 dB	-8.1 dB	-7.9 dB
80°	-11.0 dB	-11.1 dB	-9.5 dB	-9.9 dB	-8.9 dB	-9.1 dB
90°	-12.8 dB	-12.7 dB	-11.0 dB	-11.2 dB	-10.0 dB	-10.0 dB
100°	-14.4 dB	-14.3 dB	-12.0 dB	-12.3 dB	-10.6 dB	-10.8 dB
110°	-15.9 dB	-15.8 dB	-13.0 dB	-13.2 dB	-11.2 dB	-11.7 dB
120°	-17.8 dB	-17.3 dB	-14.0 dB	-14.2 dB	-13.0 dB	-13.1 dB
130°	-19.5 dB	-19.0 dB	-15.6 dB	-15.9 dB	-15.7 dB	-15.2 dB
140°	-22.4 dB	-21.2 dB	-18.7 dB	-18.3 dB	-16.2 dB	-16.8 dB
150°	-22.4 dB	-22.6 dB	-17.5 dB	-18.1 dB	-14.5 dB	-14.5 dB
160°	-20.8 dB	-21.1 dB	-14.7 dB	-14.7 dB	-12.1 dB	-11.2 dB
170°	-19.5 dB	-18.9 dB	-12.3 dB	-12.1 dB	-9.5 dB	-9.2 dB
180°	-18.9 dB	-18.1 dB	-11.5 dB	-11.3 dB	-8.5 dB	-8.5 dB

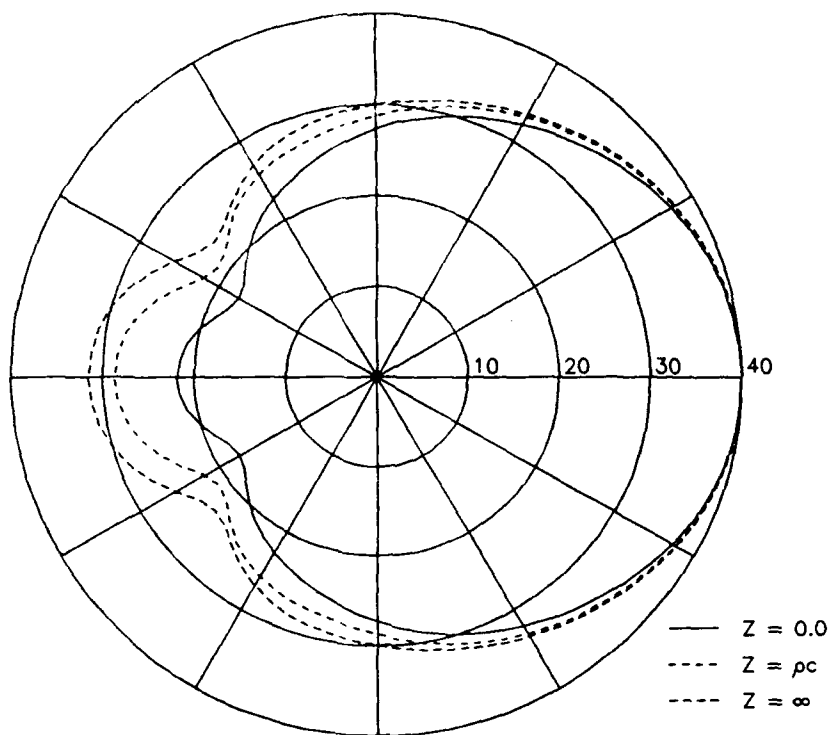


Fig. 2. Representative directivity patterns for a 90° uniformly vibrating polar cap on an impedance-coated sphere for the values of the impedance given in Table 1.

Sample Run 2: Impedance Coated Wedge With Spherical Source

This sample computes the acoustic radiation from a spherical source near a wedged-shape surface covered with an impedance material. The interesting part of this example is that the geometry is generated using equation sets 6 (spherical region), 1 (rectangular planar region), and 10 (finite element inputs).

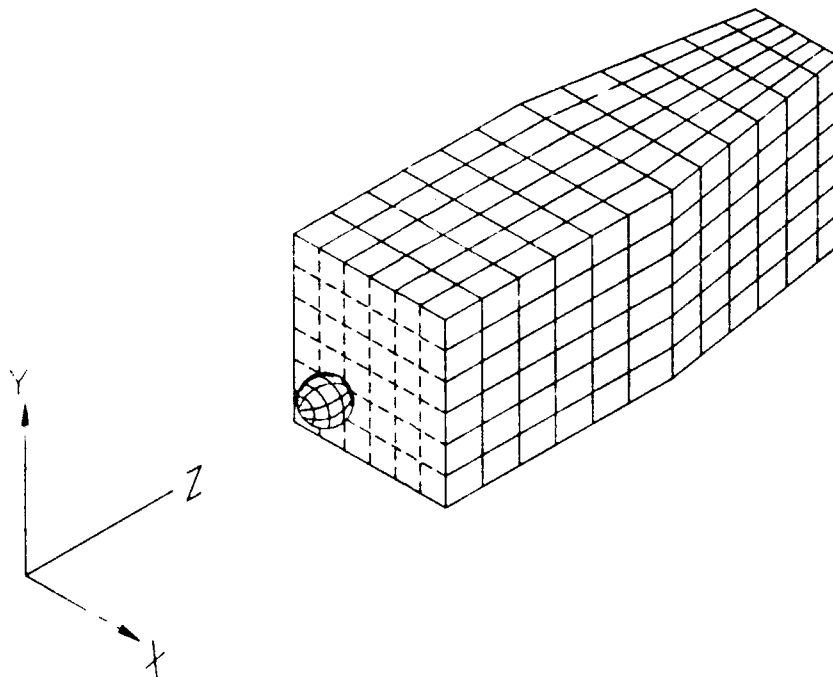


Fig. 8. Spherical source near a wedged-shaped baffle.

Program Listing of Sample Run 2

```

C   Program WEDGETES
C   WEDGE WITH VIBRATING SPHERE

C   (COMMON VARIABLE DECLARATIONS GO HERE)

      COMPLEX PMATX(14884), VMATX(14884)
      MDSIZE = 14884
      RUNID = 'WEDG'
      DATE = '23-OCT-90'
      CALL INITCM
      CALL OPNSFL
      RHO = 1000
      C = 1500

C***** impedance coating modifications *****
      NUMZ = 9
      N = 1

```



```

C ---- clear impedance for sphere
DO 10 I = N, N + (8 * 4) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
10 CONTINUE
N = N + (8 * 4)

C ---- clear impedance for SIDE1
DO 20 I = N, N + (3 * 6) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
20 CONTINUE
N = N + (3 * 6)

C ---- clear impedance for SIDE2
DO 30 I = N, N + (6 * 3) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
30 CONTINUE
N = N + (6 * 3)

C ---- clear impedance for BOTTOM
DO 40 I = N, N + (3 * 3) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
40 CONTINUE
N = N + (3 * 3)

C ---- clear impedance for FE SIDE1
DO 50 I = N, N + (1 * 18) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
50 CONTINUE
N = N + (1 * 18)

C ---- clear impedance for FE SIDE2
DO 60 I = N, N + (1 * 18) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
60 CONTINUE
N = N + (1 * 18)

C ---- load impedance for SENSOR
DO 70 I = N, N + (3 * 3) - 1
    ZCOAT(I) = CMPLX(.3e6, 0.0)
70 CONTINUE
N = N + (3 * 3)

C***** end of impedance coating modifications *****

OPEN(UNIT=MUNPRT,FILE=RUNID//'.OUT',STATUS='NEW',
1    FORM='FORMATTED')

C symmetry inputs
PI = ACOS(-1.0)

SYMtyp = 'REF'
NBLKS = 2 * 2
IRHSYM = 1
CONVERT = 1.0

C Surface Region inputs
ROTLIM = PI / NBLKS
XIRG = 0

DO 1 I = 1, 10
    CC(I) = 0.0
1 CONTINUE

DO 2 I = 1, 3
    TRANS(I) = 0.0
2 CONTINUE

C ----- sphere -----

```

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```

XNSEQNS = 4
CC( 1) = 009525 * CONVERT
CC( 2) = CC(1)+CC(1)
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = 0
XSUU = 3 1415926
XSVL = 0 000000
XSVU = 1 570796
XNSU = 0
XNSV = 0
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1 XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
C ----- SIDE1 -----
XNSEQNS = 1
CC( 1) = 0508 * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.0286+00) * CONVERT
XIZAX = +1
XSUL = 0 * CONVERT
XSUU = 0508 * CONVERT
XSVL = 0 * CONVERT
XSVU = 123525 * CONVERT
XNSU = 3
XNSV = 6
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1 XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
C ----- SIDE2 -----
XNSEQNS = 1
CC( 1) = 0508 * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.0286+00) * CONVERT
XIZAX = +2
XSUL = 0 * CONVERT
XSUU = 123825 * CONVERT
XSVL = 0 * CONVERT
XSVU = 0508 * CONVERT
XNSU = 6
XNSV = 3
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1 XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
C ----- BOTTOM -----
XNSEQNS = 1
CC( 1) = 25.025 * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = 0 * CONVERT
XSUU = 0254 * CONVERT
XSVL = 0 * CONVERT
XSVU = 0508 * CONVERT
XNSU = 3
XNSV = 3
XIORDU = 4
XIORDV = 4

```

Thompson, Dubus, & Siders

```

XIOROV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1      XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIOROU, XIOROV)
C ----- FE SIDE1 -----

XNSEQNS = 10
CC( 1) = 0      * CONVERT
CC( 2) = 0      * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = -1
XSUU = 1
XSVL = -1
XSVU = 1
XNSU = 1
XNSV = 1
XIOROU = 4
XIOROV = 4

C Read in coordinate and element data.

ICOR = 0
OPEN(UNIT=8, FILE=' IOMAGC.WED', STATUS='OLD', FORM='FORMATTED')
1401 READ(8, 1402, ERR=1403) IDUM, (COORDS(IDUM, J), J=1, 3)
1402 FORMAT(BN10, 3(BN10.0))

IF (IDUM GT. ICOR) ICOR = IDUM
IF (IDUM GT. MAXCOR) THEN
  WRITE (6, *) 'Error: Coordinate index in coordinate ' //
  'data is greater than MAXCOR.'
  STOP
END IF

GOTO 1401
1403 CLOSE(8)

C Display coordinate data.

WRITE(NUNPRT, 1407)
1407 FORMAT(1H1, ' COORDINATE DATA', /)
DO 1409 I = 1, ICOR
  WRITE(NUNPRT, 1408) I, (COORDS(I, J), J=1, 3)
1408 FORMAT(15, 6X, 3E15.4)
1409 CONTINUE

IELEM = 0
OPEN(UNIT=8 FILE=' IOELMS.WD1', STATUS='OLD', FORM='FORMATTED')
1404 READ(8, 1405, ERR=1406) IDUM, (IELTS(J, IELEM+1), J=1, 8)
1405 FORMAT(T7, 9(BN15))
IELEM = IELEM + 1
GOTO 1404
1406 CLOSE(8)

C Display element data.

WRITE(NUNPRT, 1410)
1410 FORMAT(//, ' ELEMENT DATA', /)
DO 1412 I = 1, IELEM
  WRITE(NUNPRT, 1411) I, (IELTS(J, I), J=1, 8)
1411 FORMAT(15, 10X, 8I5)
1412 CONTINUE

DO 1414 I = 1, IELEM
  DO 1413 J = 1, 8
    CC(J) = IELTS(J, I)
1413 CONTINUE

XIRG = XIRG + 1
CALL LDSURR(XIRG, 10, CC, TRNS, XIZAX,

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```

1          XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
1414 CONTINUE

```

C ----- FE SIDE2 -----

```

XNSEQNS = 10
CC( 1) = 0          * CONVERT
CC( 2) = 0          * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX  = -3
XSUL   = -1
XSUU   = 1
XSVL   = -1
XSVU   = 1
XNSU   = 1
XNSV   = 1
XIORDU = 4
XIORDV = 4

IELEM = 0
OPEN(UNIT=8,FILE=' IOELMS.WD2',STATUS='OLD',FORM='FORMATTED')
1504 READ(8,1505,ERR=1506) IDUM, (IELTS(J,IELEM+1),J=1,8)
1505 FORMAT(T7,9(BN16) )
      IELEM = IELEM + 1
      GOTO 1504
1506 CLOSE(8)

C Display element data.

WRITE(NUNPRT,1510)
1510 FORMAT(/,' ELEMENT DATA',/)
      DO 1512 I = 1, IELEM
          WRITE(NUNPRT,1511) I, (IELTS(J,I),J=1,8)
1511     FORMAT(I5,10X,8I5)
1512 CONTINUE

      DO 1514 I = 1, IELEM
          DO 1513 J = 1, 8
              CC(J) = IELTS(J, I)
1513 CONTINUE

          XIRG = XIRG + 1
          CALL LDSURR(XIRG, 10, CC, TRNS, XIZAX,
1          XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
1514 CONTINUE

```

C ----- SENSOR -----

```

XNSEQNS = 1
CC( 1) = .0286      * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX  = -3
XSUL   = 0          * CONVERT
XSUU   = .0508      * CONVERT
XSVL   = 0          * CONVERT
XSVU   = .0508      * CONVERT
XNSU   = 3
XNSV   = 3
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1 XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)

MSRFG = XIRG

```

```

C      CALL PLOTCHIEF(RUNID, NBLKS, SYMTYP, 1, 30.0, 60.0, 0.0)

      CALL PRTOU('GEOM',1)

C Define Frequency input.

      DO 99 FREQ = 2000 , 3000 , 1000

C Generate surface P and V matrices.

      CALL SURMAT(FREQ, SYMTYP, NBLKS, PMATX, VMATX, MDSIZE)

      CALL PRTOU('AREA',1)

C Decompose Matrices

      CALL DECOMM(SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)
      CALL IGSUB(NOVLS, 19, VEL, 0)

C Block # 1
      VEL( 1) = (1.0000, 0.0000)
      VEL( 2) = (1.0000, 0.0000)
      VEL( 3) = (1.0000, 0.0000)
      VEL( 4) = (1.0000, 0.0000)
      VEL( 5) = (1.0000, 0.0000)
      VEL( 6) = (1.0000, 0.0000)
      VEL( 7) = (1.0000, 0.0000)
      VEL( 8) = (1.0000, 0.0000)
      VEL( 9) = (1.0000, 0.0000)
      VEL(10) = (1.0000, 0.0000)
      VEL(11) = (1.0000, 0.0000)
      VEL(12) = (1.0000, 0.0000)
      VEL(13) = (1.0000, 0.0000)
      VEL(14) = (1.0000, 0.0000)
      VEL(15) = (1.0000, 0.0000)
      VEL(16) = (1.0000, 0.0000)
      VEL(17) = (1.0000, 0.0000)
      VEL(18) = (1.0000, 0.0000)
      VEL(19) = (1.0000, 0.0000)
      VEL(20) = (1.0000, 0.0000)
      VEL(21) = (1.0000, 0.0000)
      VEL(22) = (1.0000, 0.0000)
      VEL(23) = (1.0000, 0.0000)
      VEL(24) = (1.0000, 0.0000)
      VEL(25) = (1.0000, 0.0000)
      VEL(26) = (1.0000, 0.0000)
      VEL(27) = (1.0000, 0.0000)
      VEL(28) = (1.0000, 0.0000)
      VEL(29) = (1.0000, 0.0000)
      VEL(30) = (1.0000, 0.0000)
      VEL(31) = (1.0000, 0.0000)
      VEL(32) = (1.0000, 0.0000)
      VEL(33) = (0.0000, 0.0000)
      VEL(34) = (0.0000, 0.0000)
      VEL(35) = (0.0000, 0.0000)
      VEL(36) = (0.0000, 0.0000)
      VEL(37) = (0.0000, 0.0000)
      VEL(38) = (0.0000, 0.0000)
      VEL(39) = (0.0000, 0.0000)
      VEL(40) = (0.0000, 0.0000)
      VEL(41) = (0.0000, 0.0000)
      VEL(42) = (0.0000, 0.0000)
      VEL(43) = (0.0000, 0.0000)
      VEL(44) = (0.0000, 0.0000)
      VEL(45) = (0.0000, 0.0000)
      VEL(46) = (0.0000, 0.0000)
      VEL(47) = (0.0000, 0.0000)
      VEL(48) = (0.0000, 0.0000)
      VEL(49) = (0.0000, 0.0000)
      VEL(50) = (0.0000, 0.0000)
      VEL(51) = (0.0000, 0.0000)
      VEL(52) = (0.0000, 0.0000)
      VEL(53) = (0.0000, 0.0000)

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VEL(54) = (0.0000, 0.0000)
 VEL(55) = (0.0000, 0.0000)
 VEL(56) = (0.0000, 0.0000)
 VEL(57) = (0.0000, 0.0000)
 VEL(58) = (0.0000, 0.0000)
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 VEL(61) = (0.0000, 0.0000)
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 VEL(69) = (0.0000, 0.0000)
 VEL(70) = (0.0000, 0.0000)
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 VEL(75) = (0.0000, 0.0000)
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 VEL(77) = (0.0000, 0.0000)
 VEL(78) = (0.0000, 0.0000)
 VEL(79) = (0.0000, 0.0000)
 VEL(80) = (0.0000, 0.0000)
 VEL(81) = (0.0000, 0.0000)
 VEL(82) = (0.0000, 0.0000)
 VEL(83) = (0.0000, 0.0000)
 VEL(84) = (0.0000, 0.0000)
 VEL(85) = (0.0000, 0.0000)
 VEL(86) = (0.0000, 0.0000)
 VEL(87) = (0.0000, 0.0000)
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 VEL(95) = (0.0000, 0.0000)
 VEL(96) = (0.0000, 0.0000)
 VEL(97) = (0.0000, 0.0000)
 VEL(98) = (0.0000, 0.0000)
 VEL(99) = (0.0000, 0.0000)
 VEL(100) = (0.0000, 0.0000)
 VEL(101) = (0.0000, 0.0000)
 VEL(102) = (0.0000, 0.0000)
 VEL(103) = (0.0000, 0.0000)
 VEL(104) = (0.0000, 0.0000)
 VEL(105) = (0.0000, 0.0000)
 VEL(106) = (0.0000, 0.0000)
 VEL(107) = (0.0000, 0.0000)
 VEL(108) = (0.0000, 0.0000)
 VEL(109) = (0.0000, 0.0000)
 VEL(110) = (0.0000, 0.0000)
 VEL(111) = (0.0000, 0.0000)
 VEL(112) = (0.0000, 0.0000)
 VEL(113) = (0.0000, 0.0000)
 VEL(114) = (0.0000, 0.0000)
 VEL(115) = (0.0000, 0.0000)
 VEL(116) = (0.0000, 0.0000)
 VEL(117) = (0.0000, 0.0000)
 VEL(118) = (0.0000, 0.0000)
 VEL(119) = (0.0000, 0.0000)
 VEL(120) = (0.0000, 0.0000)
 VEL(121) = (0.0000, 0.0000)
 VEL(122) = (0.0000, 0.0000)
 CALL TOSUB(NVEL, 1, VEL, NWDVEC)

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C Generate Surface Pressures.

CALL SURPRS(FREQ, SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

CALL PRTOU('VEL',1)

CALL PRTOU('SP',1)

FLDTYP = 'FAR '

NUMTHP = 19

DO 25 I = 1, NUMTHP

THTPHI(1, I) = (I - 1) * 10

THTPHI(2, I) = 0.0

25 CONTINUE

C Calculate FAR Field Matrices

CALL FLDMAT(FREQ, SYMTYP, FLDTYP, NBLKS, PMATX, VMATX, MDSIZE)

IFFNRM = 0

C Calculate Far-Field Pressures.

CALL FLDPRES(FREQ, FLDTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

CALL PRTOU(FLDTYP, 0)

99 CONTINUE

STOP

END

Output Listing of Sample Run 2

1 COORDINATE DATA

1	0.3635E-08	0.5080E-01	0.1624E+00
2	0.4627E-08	0.5080E-01	0.1694E+00
3	0.5620E-08	0.5080E-01	0.1863E+00
4	0.6612E-08	0.5080E-01	0.2032E+00
5	0.7605E-08	0.5080E-01	0.2202E+00
6	0.8597E-08	0.5080E-01	0.2371E+00
7	0.9590E-08	0.5080E-01	0.2540E+00
8	0.1093E-01	0.5080E-01	0.1624E+00
9	0.1652E-01	0.5080E-01	0.1694E+00
10	0.1411E-01	0.5080E-01	0.1863E+00
11	0.1270E-01	0.5080E-01	0.2032E+00
12	0.1129E-01	0.5080E-01	0.2202E+00
13	0.9878E-02	0.5080E-01	0.2371E+00
14	0.8467E-02	0.5080E-01	0.2540E+00
15	0.3387E-01	0.5080E-01	0.1624E+00
16	0.3104E-01	0.5080E-01	0.1694E+00
17	0.2822E-01	0.5080E-01	0.1863E+00
18	0.2540E-01	0.5080E-01	0.2032E+00
19	0.2258E-01	0.5080E-01	0.2202E+00
20	0.1976E-01	0.5080E-01	0.2371E+00
21	0.1693E-01	0.5080E-01	0.2540E+00
22	0.5080E-01	0.5080E-01	0.1624E+00
23	0.4657E-01	0.5080E-01	0.1694E+00
24	0.4233E-01	0.5080E-01	0.1863E+00
25	0.3810E-01	0.5080E-01	0.2032E+00
26	0.3387E-01	0.5080E-01	0.2202E+00
27	0.2963E-01	0.5080E-01	0.2371E+00
28	0.2540E-01	0.5080E-01	0.2540E+00
29	0.5080E-01	0.3387E-01	0.1624E+00
30	0.4657E-01	0.3387E-01	0.1694E+00
31	0.4233E-01	0.3387E-01	0.1863E+00
32	0.3810E-01	0.3387E-01	0.2032E+00
33	0.3387E-01	0.3387E-01	0.2202E+00
34	0.2963E-01	0.3387E-01	0.2371E+00
35	0.2540E-01	0.3387E-01	0.2540E+00
36	0.5080E-01	0.1693E-01	0.1624E+00
37	0.4657E-01	0.1693E-01	0.1694E+00

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38	0.4233E-01	0.1600E-01	0.1603E-00
39	0.3010E-01	0.1600E-01	0.2002E-00
40	0.3387E-01	0.1603E-01	0.2202E-00
41	0.2983E-01	0.1603E-01	0.2311E-00
42	0.2540E-01	0.1603E-01	0.2540E-00
43	0.5080E-01	0.1641E-01	0.1504E-00
44	0.4657E-01	0.1640E-01	0.1604E-00
45	0.4233E-01	0.1640E-01	0.1603E-00
46	0.3810E-01	0.1604E-00	0.2002E-00
47	0.3387E-01	0.1604E-00	0.2202E-00
48	0.2905E-01	0.1604E-00	0.2311E-00
49	0.2540E-01	0.1604E-00	0.2540E-00

ELEMENT DATA

1	1	2	3	4	5	6	7	8
2	2	3	10	11	12	13	14	15
3	3	4	11	12	13	14	15	16
4	4	5	12	13	14	15	16	17
5	5	6	13	14	15	16	17	18
6	6	7	14	15	16	17	18	19
7	7	8	15	16	17	18	19	20
8	8	9	16	17	18	19	20	21
9	9	10	17	18	19	20	21	22
10	10	11	18	19	20	21	22	23
11	11	12	19	20	21	22	23	24
12	12	13	20	21	22	23	24	25
13	13	14	21	22	23	24	25	26
14	14	15	22	23	24	25	26	27
15	15	16	23	24	25	26	27	28
16	16	17	24	25	26	27	28	29
17	17	18	25	26	27	28	29	30
18	18	19	26	27	28	29	30	31
19	19	20	27	28	29	30	31	32
20	20	21	28	29	30	31	32	33
21	21	22	29	30	31	32	33	34
22	22	23	30	31	32	33	34	35
23	23	24	31	32	33	34	35	36
24	24	25	32	33	34	35	36	37
25	25	26	33	34	35	36	37	38
26	26	27	34	35	36	37	38	39
27	27	28	35	36	37	38	39	40
28	28	29	36	37	38	39	40	41
29	29	30	37	38	39	40	41	42
30	30	31	38	39	40	41	42	43
31	31	32	39	40	41	42	43	44
32	32	33	40	41	42	43	44	45
33	33	34	41	42	43	44	45	46
34	34	35	42	43	44	45	46	47
35	35	36	43	44	45	46	47	48
36	36	37	44	45	46	47	48	49
37	37	38	45	46	47	48	49	50
38	38	39	46	47	48	49	50	51
39	39	40	47	48	49	50	51	52
40	40	41	48	49	50	51	52	53
41	41	42	49	50	51	52	53	54
42	42	43	50	51	52	53	54	55

1

PROGRAM C H I F F S 3 RUN WEDG DATE 23-OCT-9

REGION	NSEQNS	NSU	NSV	SUL	SUU	SVL	SVU	IORDRU	IORDV
1	6	3	4	0.00000E+00	0.314159E+01	0.000000E+00	0.157080E+01	4	4
2	1	3	5	0.000000E+00	0.508000E-01	0.000000E+00	0.123825E+00	4	4
3	1	5	3	0.000000E+00	0.113825E+00	0.000000E+00	0.508000E-01	4	4
4	1	3	3	0.000000E+00	0.284000E-01	0.000000E+00	0.508000E-01	4	4
5	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
6	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
7	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
8	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
9	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
10	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
11	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
12	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
13	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
14	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4
15	10	1	1	-1.00000E+01	0.100000E+01	-1.00000E+01	0.100000E+01	4	4

Thompson, Dubus, & Siders

[illegible]

REGION	- TRANSLATION (T1,T2,T3),			IZAX
1	0.000000E+00	0.000000E+00	0.000000E+00	3
2	0.000000E+00	0.000000E+00	0.286000E-01	1
3	0.000000E+00	0.000000E+00	0.286000E-01	2
4	0.000000E+00	0.000000E+00	0.000000E+00	3
5	0.000000E+00	0.000000E+00	0.000000E+00	3
6	0.000000E+00	0.000000E+00	0.000000E+00	3
7	0.000000E+00	0.000000E+00	0.000000E+00	3
8	0.000000E+00	0.000000E+00	0.000000E+00	3
9	0.000000E+00	0.000000E+00	0.000000E+00	3
10	0.000000E+00	0.000000E+00	0.000000E+00	3
11	0.000000E+00	0.000000E+00	0.000000E+00	3
12	0.000000E+00	0.000000E+00	0.000000E+00	3
13	0.000000E+00	0.000000E+00	0.000000E+00	3
14	0.000000E+00	0.000000E+00	0.000000E+00	3
15	0.000000E+00	0.000000E+00	0.000000E+00	3
16	0.000000E+00	0.000000E+00	0.000000E+00	3
17	0.000000E+00	0.000000E+00	0.000000E+00	3
18	0.000000E+00	0.000000E+00	0.000000E+00	3
19	0.000000E+00	0.000000E+00	0.000000E+00	3
20	0.000000E+00	0.000000E+00	0.000000E+00	3
21	0.000000E+00	0.000000E+00	0.000000E+00	3
22	0.000000E+00	0.000000E+00	0.000000E+00	3
23	0.000000E+00	0.000000E+00	0.000000E+00	3
24	0.000000E+00	0.000000E+00	0.000000E+00	3
25	0.000000E+00	0.000000E+00	0.000000E+00	3
26	0.000000E+00	0.000000E+00	0.000000E+00	3
27	0.000000E+00	0.000000E+00	0.000000E+00	3
28	0.000000E+00	0.000000E+00	0.000000E+00	3
29	0.000000E+00	0.000000E+00	0.000000E+00	3
30	0.000000E+00	0.000000E+00	0.000000E+00	3
31	0.000000E+00	0.000000E+00	0.000000E+00	3
32	0.000000E+00	0.000000E+00	0.000000E+00	3
33	0.000000E+00	0.000000E+00	0.000000E+00	3
34	0.000000E+00	0.000000E+00	0.000000E+00	3
35	0.000000E+00	0.000000E+00	0.000000E+00	3
36	0.000000E+00	0.000000E+00	0.000000E+00	3
37	0.000000E+00	0.000000E+00	0.000000E+00	3
38	0.000000E+00	0.000000E+00	0.000000E+00	3
39	0.000000E+00	0.000000E+00	0.000000E+00	3
40	0.000000E+00	0.000000E+00	0.000000E+00	3
41	0.000000E+00	0.000000E+00	0.000000E+00	-3

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REGION - CCS

[illegible]

NO. OF SURFACE AREAS 122 NO. OF SURFACE FIELD POINTS = 122

I

PRG SAGE C I 0 1 8 8 RUN WEDC DATE 23-OCT-9

FREQUENCY= 2000 0 F=0= 1000 0 C= 1500 0

SYMMETRY TYPE= REF NO OF BLOCKS= 4

VELOCITIES (BLK#, AREA, REAL, IMAG, MAG, ANG)

1	1	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	2	0.130000E+01	0.000000E+00	0.130000E+01	0.00
1	3	0.100000E+01	0.000000E+00	0.100000E+01	0.00
1	4	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	5	0.120000E+01	0.000000E+00	0.120000E+01	0.00
1	6	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	7	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	8	0.100000E+01	0.000000E+00	0.100000E+01	0.00
1	9	0.100000E+01	0.000000E+00	0.100000E+01	0.00
1	10	0.100000E+01	0.000000E+00	0.100000E+01	0.00
1	11	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	12	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	13	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	14	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	15	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	16	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	17	0.120000E+01	0.000000E+00	0.100000E+01	0.00
1	18	0.120000E+01	0.000000E+00	0.100000E+01	0.00

Thompson, Dubus, & Siders

[illegible]

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1 91	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 92	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 93	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 94	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 95	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 96	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 97	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 98	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 99	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 100	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 101	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 102	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 103	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 104	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 105	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 106	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 107	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 108	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 109	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 110	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 111	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 112	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 113	0.000000E+00	0.000000E+00	0.000000E+00	0.00
1 114	-0.919748E-01	-0.681887E-01	0.114495E+00	-143.45
1 115	-0.710678E-01	-0.344366E-01	0.789716E-01	-154.15
1 116	-0.495808E-01	-0.135340E-01	0.513755E-01	-164.73
1 117	-0.710671E-01	-0.344369E-01	0.789711E-01	-154.15
1 118	-0.583367E-01	-0.191611E-01	0.614030E-01	-161.82
1 119	-0.434601E-01	-0.847442E-02	0.442768E-01	-168.97
1 120	-0.495583E-01	-0.135344E-01	0.513732E-01	-164.73
1 121	-0.434585E-01	-0.847467E-02	0.442771E-01	-168.97
1 122	-0.353840E-01	-0.477029E-02	0.356843E-01	-172.32

*** FULL VELOCITY SYMMETRY ***

1

PROGRAM C H I E F 8 8 RUN WEDG DATE 23-OCT-9

FREQUENCY= 2000.0 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= REF NO. OF BLOCKS= 4

SURFACE PRESSURES (BLK#, AREA#, REAL, IMAG, MAG, ANG)

1 1	0.190689E+05	0.104885E+06	0.106604E+06	79.70
1 2	0.190689E+05	0.104885E+06	0.106604E+06	79.70
1 3	0.190689E+05	0.104885E+06	0.106604E+06	79.70
1 4	0.190689E+05	0.104885E+06	0.106604E+06	79.70
1 5	0.180495E+05	0.105801E+06	0.107330E+06	80.32
1 6	0.180497E+05	0.105801E+06	0.107329E+06	80.32
1 7	0.180497E+05	0.105801E+06	0.107330E+06	80.32
1 8	0.180496E+05	0.105801E+06	0.107330E+06	80.32
1 9	0.165634E+05	0.106442E+06	0.107723E+06	81.16
1 10	0.165638E+05	0.106442E+06	0.107723E+06	81.15
1 11	0.165638E+05	0.106442E+06	0.107723E+06	81.15
1 12	0.165634E+05	0.106442E+06	0.107723E+06	81.16
1 13	0.150097E+05	0.107242E+06	0.108287E+06	82.03
1 14	0.150101E+05	0.107241E+06	0.108287E+06	82.03
1 15	0.150101E+05	0.107241E+06	0.108286E+06	82.03
1 16	0.150096E+05	0.107241E+06	0.108287E+06	82.03
1 17	0.136903E+05	0.108067E+06	0.108931E+06	82.78
1 18	0.136905E+05	0.108066E+06	0.108930E+06	82.78
1 19	0.136905E+05	0.108066E+06	0.108930E+06	82.78
1 20	0.136902E+05	0.108066E+06	0.108930E+06	82.78
1 21	0.127172E+05	0.108774E+06	0.109515E+06	83.33
1 22	0.127172E+05	0.108773E+06	0.109514E+06	83.33
1 23	0.127173E+05	0.108774E+06	0.109515E+06	83.33
1 24	0.127173E+05	0.108774E+06	0.109515E+06	83.33
1 25	0.120968E+05	0.109246E+06	0.109914E+06	83.68
1 26	0.120969E+05	0.109247E+06	0.109914E+06	83.68
1 27	0.120969E+05	0.109247E+06	0.109914E+06	83.68
1 28	0.120969E+05	0.109247E+06	0.109914E+06	83.68
1 29	0.118485E+05	0.108926E+06	0.109569E+06	83.79

Thompson, Dubus, & Siders

1 30	0.118484E+05	0.108928E+06	0.109589E+06	83.79
1 31	0.118485E+05	0.108928E+06	0.109589E+06	83.79
1 32	0.118485E+05	0.108928E+06	0.109589E+06	83.79
1 33	0.732883E+04	0.258308E+04	0.777072E+04	19.42
1 34	0.585173E+04	0.108433E+04	0.595135E+04	10.50
1 35	0.486771E+04	0.886709E+02	0.486852E+04	1.04
1 36	0.488883E+04	-0.021921E+03	0.413388E+04	-8.05
1 37	0.340278E+04	-0.114628E+04	0.359867E+04	-18.02
1 38	0.276505E+04	-0.153748E+04	0.316378E+04	-29.00
1 39	0.706355E+04	0.229893E+04	0.742824E+04	18.03
1 40	0.572989E+04	0.962305E+03	0.580994E+04	9.53
1 41	0.480102E+04	0.277307E+02	0.480190E+04	0.33
1 42	0.484804E+04	-0.055842E+03	0.489882E+04	-9.20
1 43	0.337590E+04	-0.116542E+04	0.357140E+04	-19.05
1 44	0.274827E+04	-0.154748E+04	0.315480E+04	-29.38
1 45	0.604398E+04	0.192919E+04	0.691838E+04	18.19
1 46	0.553895E+04	0.701202E+03	0.559378E+04	8.03
1 47	0.469735E+04	-0.702261E+02	0.469787E+04	-0.06
1 48	0.398888E+04	-0.712458E+03	0.404393E+04	-10.15
1 49	0.333319E+04	-0.119883E+04	0.354222E+04	-19.78
1 50	0.272385E+04	-0.158510E+04	0.314148E+04	-29.08
1 51	0.733214E+04	0.258408E+04	0.777417E+04	19.41
1 52	0.706309E+04	0.229974E+04	0.743111E+04	18.03
1 53	0.604558E+04	0.192970E+04	0.692008E+04	18.19
1 54	0.585742E+04	0.108816E+04	0.595728E+04	10.51
1 55	0.573438E+04	0.903804E+03	0.581481E+04	9.54
1 56	0.554168E+04	0.702138E+03	0.559659E+04	8.03
1 57	0.487716E+04	0.918527E+02	0.487803E+04	1.08
1 58	0.480959E+04	0.303016E+02	0.480968E+04	0.36
1 59	0.470178E+04	-0.087490E+02	0.470228E+04	-0.04
1 60	0.410283E+04	-0.016407E+03	0.414888E+04	-8.54
1 61	0.405918E+04	-0.051134E+03	0.411107E+04	-9.11
1 62	0.398815E+04	-0.709898E+03	0.405084E+04	-10.09
1 63	0.343146E+04	-0.113622E+04	0.361468E+04	-18.32
1 64	0.339943E+04	-0.115717E+04	0.359090E+04	-18.00
1 65	0.334652E+04	-0.119413E+04	0.355319E+04	-19.04
1 66	0.282.7 E+04	-0.151727E+04	0.320379E+04	-28.27
1 67	0.279527E+04	-0.153062E+04	0.318890E+04	-28.70
1 68	0.275083E+04	-0.155530E+04	0.318006E+04	-29.48
1 69	-0.224617E+03	-0.200137E+04	0.201393E+04	-96.40
1 70	-0.199984E+03	-0.200113E+04	0.201110E+04	-95.71
1 71	-0.130684E+03	-0.200528E+04	0.200952E+04	-93.73
1 72	-0.199928E+03	-0.200538E+04	0.201533E+04	-95.69
1 73	-0.177450E+03	-0.200476E+04	0.201259E+04	-95.06
1 74	-0.114588E+03	-0.200740E+04	0.201067E+04	-93.27
1 75	-0.145792E+03	-0.202964E+04	0.203487E+04	-94.11
1 76	-0.127149E+03	-0.202835E+04	0.203233E+04	-93.59
1 77	-0.769867E+02	-0.202799E+04	0.202945E+04	-92.17
1 78	0.230584E+04	-0.176759E+04	0.200539E+04	-37.47
1 79	0.186816E+04	-0.192688E+04	0.208366E+04	-45.88
1 80	0.145415E+04	-0.203076E+04	0.249770E+04	-54.40
1 81	0.106272E+04	-0.208606E+04	0.234118E+04	-63.00
1 82	0.092089E+03	-0.209777E+04	0.220899E+04	-71.74
1 83	0.336047E+03	-0.207088E+04	0.269795E+04	-80.78
1 84	0.226388E+04	-0.177805E+04	0.289318E+04	-37.07
1 85	0.105141E+04	-0.193147E+04	0.267550E+04	-46.21
1 86	0.144148E+04	-0.203328E+04	0.249240E+04	-54.67
1 87	0.105353E+04	-0.208721E+04	0.233803E+04	-63.22
1 88	0.086285E+03	-0.209820E+04	0.220758E+04	-71.89
1 89	0.333982E+03	-0.207028E+04	0.209704E+04	-80.04
1 90	0.223927E+04	-0.179308E+04	0.286870E+04	-38.69
1 91	0.181595E+04	-0.194219E+04	0.265890E+04	-46.92
1 92	0.141375E+04	-0.204028E+04	0.248221E+04	-55.28
1 93	0.103309E+04	-0.209267E+04	0.233378E+04	-63.73
1 94	0.072972E+03	-0.210494E+04	0.220990E+04	-72.27
1 95	0.328846E+03	-0.208215E+04	0.210798E+04	-81.03
1 96	0.214204E+04	-0.183110E+04	0.281802E+04	-40.53
1 97	0.171250E+04	-0.197426E+04	0.201350E+04	-49.06
1 98	0.131468E+04	-0.208216E+04	0.244558E+04	-57.48
1 99	0.941758E+03	-0.210342E+04	0.230462E+04	-65.88
1 100	0.590065E+03	-0.210391E+04	0.218525E+04	-74.32
1 101	0.256657E+03	-0.206788E+04	0.208374E+04	-82.92

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1 102	0.214018E+04	-0.183033E+04	0.281811E+04	-40.54
1 103	0.189623E+04	-0.197963E+04	0.260693E+04	-49.41
1 104	0.129266E+04	-0.208865E+04	0.243932E+04	-58.00
1 105	0.917178E+03	-0.210939E+04	0.230015E+04	-66.50
1 106	0.584417E+03	-0.210880E+04	0.218303E+04	-75.02
1 107	0.226739E+03	-0.207149E+04	0.208388E+04	-83.76
1 108	0.214650E+04	-0.182729E+04	0.281894E+04	-40.41
1 109	0.169558E+04	-0.198024E+04	0.260698E+04	-49.43
1 110	0.128617E+04	-0.207080E+04	0.243877E+04	-58.12
1 111	0.910571E+03	-0.211201E+04	0.229994E+04	-66.68
1 112	0.556222E+03	-0.211142E+04	0.218346E+04	-75.24
1 113	0.216311E+03	-0.207388E+04	0.208511E+04	-84.05
1 114	0.275924E+05	0.204568E+05	0.343485E+05	36.55
1 115	0.213203E+05	0.103310E+05	0.236916E+05	25.85
1 116	0.148682E+05	0.406019E+04	0.154128E+05	15.27
1 117	0.213201E+05	0.103311E+05	0.236913E+05	25.85
1 118	0.175010E+05	0.574834E+04	0.184209E+05	18.18
1 119	0.130380E+05	0.254233E+04	0.132836E+05	11.03
1 120	0.148675E+05	0.406031E+04	0.154120E+05	15.27
1 121	0.130376E+05	0.254240E+04	0.132831E+05	11.03
1 122	0.106092E+05	0.143109E+04	0.107053E+05	7.68

*** FULL VELOCITY SYMMETRY ***

POWER OUT(KW)= 0.003

Sample Run 3: Conical Source With Circular Planar Baffle Radiation Matrix

The geometry for this problem was generated using DISPLAY3D⁴, which is available to all CHIEF users. Run 3 computes a radiation matrix using both the subroutines ZRADMX and ZRADMI since the circular planar baffle has an impedance coating. Also the cone is a new surface in CCUNMD.

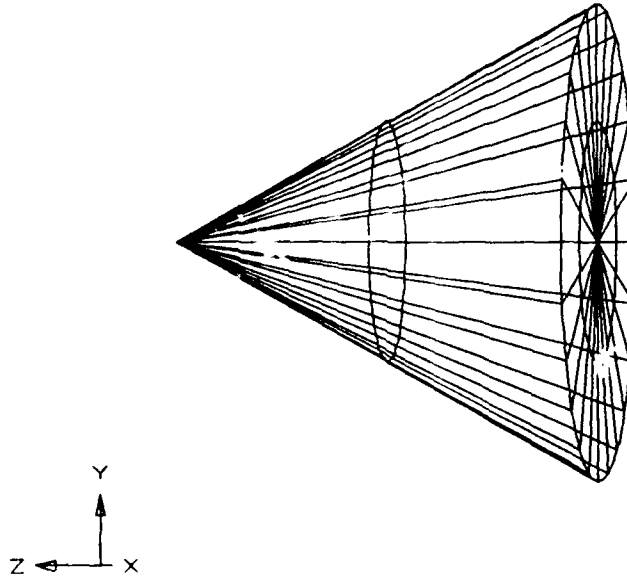


Fig. 4. A radiating cone with a circular planar baffle.

Program Listing of Sample Run 3

```

C   Program CONE
C   Example Problem of a cone topped by an impedance surface

C   (COMMON VARIABLE DECLARATIONS GO HERE)

      COMPLEX PMATX( 152), VMATX( 152)
      MDSIZE = 152
      RUNID = 'CONE'
      DATE = '25-FEB-91'
      CALL INITCJ
      CALL OPNSCJ
      RHO = 1000
      C = 1500

C***** impedance coating modifications *****
      NUMZ = 4
      N = 1
    
```

```

C ---- clear impedance for The Cone
DO 10 I = N, N + (2 * 2) - 1
    ZCOAT(I) = CMPLX(0.0, 0.0)
10 CONTINUE
N = N + (2 * 2)

C ---- clear impedance for Circular Imp. Cap
DO 20 I = N, N + (2 * 2) - 1
    ZCOAT(I) = CMPLX(0.0, 1.0E+4)
20 CONTINUE
N = N + (2 * 2)

C***** end of impedance clearing modifications *****

OPEN(UNIT=NONUNIT, FILE=RUNID/, IOSTAT=STATUS, STATUS='NEW',
1    FORM='FORMATTED')

C symmetry inputs
PI = 3.141592653589793
SYMTYP = 'RDT'
NBLKS = 12
IRHSH = 1
JUNV = 0

C Surface Region inputs
RDTM = PI / NBLKS
XIRG = 0

DO 1 I = 1, 10
    CC(I) = 0.0
1 CONTINUE

DO 2 I = 1, 3
    TRNS(I) = 0.0
2 CONTINUE

C ----- The Cone -----
XNSEQNS = 13
CC(1) = 1 * CONVERT
CC(2) = 2 * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = -0.26160
XSUU = 0.26180
XSVL = 0
XSVU = 2 * CONVERT
XNSU = 2
XNSV = -2
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1    XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)
C ----- Circular Imp. Cap -----
XNSEQNS = 2
CC(1) = 0 * CONVERT
TRNS(1) = (0.00E+00) * CONVERT
TRNS(2) = (0.00E+00) * CONVERT
TRNS(3) = (0.00E+00) * CONVERT
XIZAX = +3
XSUL = 0 * CONVERT
XSUU = 1 * CONVERT
XSVL = 0.26160
XSVU = 0.26180

```


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```

XNSU   = 2
XNSV   = 2
XIORDU = 4
XIORDV = 4
XIRG = XIRG + 1
CALL LDSURR(XIRG, XNSEQNS, CC, TRNS, XIZAX,
1        XSUL, XSUU, XSVL, XSVU, XNSU, XNSV, XIORDU, XIORDV)

NSREG = XIRG

C      CALL PLOTCHIEF(RUNID, NBLKS, SYMTYP, 1, 30.0, 60.0, 0.0)

C Define Frequency input.
      FREQ   = 100

C Generate surface P and V matrices.
      CALL SURMAT(FREQ, SYMTYP, NBLKS, PMATX, VMATX, MDSIZE)

C Decompose Matrices
      CALL DECOMM(SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)
      CALL IOSUB(NDVELS, 10, VEL, 0)
C Block # 1
      VEL( 1) = (1.0000, 0.0000)
      VEL( 2) = (1.0000, 0.0000)
      VEL( 3) = (1.0000, 0.0000)
      VEL( 4) = (1.0000, 0.0000)
      VEL( 5) = (0.0000, 0.0000)
      VEL( 6) = (0.0000, 0.0000)
      VEL( 7) = (0.0000, 0.0000)
      VEL( 8) = (0.0000, 0.0000)
      CALL IOSUB(NDVELS, 1, VEL, NWDVEC)

C Generate Surface Pressures.
      CALL SURPRS(FREQ, SYMTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

      FLDTYP = 'FAR '
      NUMTHP = 19
      DO 25 I = 1, NUMTHP
          THTPHI(1, I) = (I - 1) * 5
          THTPHI(2, I) = 0.0
25      CONTINUE

C Calculate FAR Field Matrices
      CALL FLDMAT(FREQ, SYMTYP, FLDTYP, NBLKS, PMATX, VMATX, MDSIZE)
      IFFNRW = 19

C Calculate Far-Field Pressures.
      CALL FLDPRS(FREQ, FLDTYP, NBLKS, IRHSYM, PMATX, VMATX, MDSIZE)

      CALL PRTOUT(FLDTYP, 0)

      STOP
      END

```

Output Listing of Sample Run 3

FREQUENCY= 100.0 RHO= 1000.0 C= 1500.0

SYMMETRY TYPE= ROT NO. OF BLOCKS= 12

FAR-FIELD PRESSURES (PHI, THETA, FFP(RL, IM, MAG, ANG) , NORMALIZED PATTERN, SOURCE LEVEL, DI)

0.00	0.00	-.186832E+03	0.310326E+04	0.310888E+04	93.45	0.02
0.00	5.00	-.186244E+03	0.310326E+04	0.310886E+04	93.43	0.02
0.00	10.00	-.184483E+03	0.310328E+04	0.310875E+04	93.40	0.02

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0.00	15.00	- .181564E+03	0.310330E+04	0.310060E+04	93.35	0.02
0.00	20.00	- .177508E+03	0.310332E+04	0.310039E+04	93.27	0.01
0.00	25.00	- .172348E+03	0.310335E+04	0.310013E+04	93.18	0.01
0.00	30.00	- .168118E+03	0.310338E+04	0.310782E+04	93.06	0.01
0.00	35.00	- .158870E+03	0.310341E+04	0.310748E+04	92.92	0.01
0.00	40.00	- .150659E+03	0.310344E+04	0.310710E+04	92.78	0.01
0.00	45.00	- .141548E+03	0.310348E+04	0.310669E+04	92.61	0.01
0.00	50.00	- .131601E+03	0.310348E+04	0.310627E+04	92.43	0.01
0.00	55.00	- .120899E+03	0.310348E+04	0.310583E+04	92.23	0.01
0.00	60.00	- .109523E+03	0.310347E+04	0.310540E+04	92.02	0.01
0.00	65.00	- .975579E+02	0.310344E+04	0.310498E+04	91.80	0.01
0.00	70.00	- .850955E+02	0.310340E+04	0.310458E+04	91.57	0.00
0.00	75.00	- .722337E+02	0.310335E+04	0.310417E+04	91.33	0.00
0.00	80.00	- .590613E+02	0.310325E+04	0.310381E+04	91.09	0.00
0.00	85.00	- .458878E+02	0.310314E+04	0.310348E+04	90.84	0.00
0.00	90.00	- .322114E+02	0.310301E+04	0.310318E+04	90.59	0.00

* DIRECTION FOR PATTERN NORMALIZATION

LIMITATIONS

The following existing features of CHIEF have not been addressed in the context of a partially impedance coated radiator:

- Point source check. There seems to be no reason that this option cannot be used in its unmodified form; the results from the modified CHIEF program supply the actual surface velocities all over the radiator which will aid one in assigning relative strengths to the hypothetical point sources.
- Radiator in an infinite rigid baffle. This feature has not been modified for the case of an impedance coated baffle; furthermore, the Green's function used in the existing formulation of this problem is applicable only to the case of an infinite-plane, rigid baffle.
- Scattering problems. This feature has not been modified for the case of a partially or totally impedance-coated scatterer; the present development in CHIEF is applicable only to rigid scatterers.

The following feature of CID exists for a partially impedance coated radiator:

- Impedance symmetry must be the same as body, even if there is no velocity symmetry.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Michele McCollum for her many valuable comments. Also thanks to Mitch Bolling and Patrick Klippel for programming and verifying the CHIEF and CID modifications.

REFERENCES

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4. C. M. Siders and D. M. Bolling, Jr., "DISPLAY3D, A Graphics Preprocessor for CHIEF," NRL Memorandum Report 6709, 27 December 1990.

APPENDIX A - THEORETICAL CONSIDERATION

A1: Basic Equations for Impedance Surfaces

The CHIEF program develops a matrix equation for the unknown surface pressure P of the form

$$[A]P = [B]V. \quad (A1.1)$$

Assuming the frequency is not at or near one of the so-called forbidden frequencies where the coefficient matrix A becomes ill-conditioned, or in fact its determinant vanishes, then one can solve Eq. (A1.1) for the surface pressure P . Now knowing both P and V on the surface of the radiator, CHIEF proceeds to compute the radiated pressure field at any point external to the surface; in particular, one usually wishes to know the far-field pressure distribution.

Now consider a radiator part whose surface has a prescribed normal velocity V_R while the remainder, Region I, is coated with the arbitrary complex locally reacting impedance layer Z . Neither of these regions need be a single contiguous region; i.e., the active and the impedance-coated areas could be a number of noncontiguous or, in fact, even disjoint surfaces. The subscripts R and I merely indicate a convenient subdivision of the problem into the two different boundary condition regions. Accordingly, matrix Eq. (A1.1) can be partitioned as follows:

$$\begin{bmatrix} A_{RR} & A_{RI} \\ A_{IR} & A_{II} \end{bmatrix} \begin{bmatrix} P_R \\ P_I \end{bmatrix} = \begin{bmatrix} B_{RR} & B_{RI} \\ B_{IR} & B_{II} \end{bmatrix} \begin{bmatrix} V_R \\ V_I \end{bmatrix}. \quad (A1.2)$$

Note that the impedance-coated regions are relegated to the bottom positions in the matrix equation, a choice that is followed throughout this discussion and in the modifications of the computer code. There would appear to be three sets of unknown quantities in Eq. (A1.2), the pressures P_R and P_I as well as the velocity V_I ; i.e., only velocity V_R has been specified. However, while neither P_I nor V_I is known, their ratio defines, or is defined by, the impedance coating on Region I as

$$P_I/V_I = -Z. \quad (A1.3)$$

The minus sign in this equation deserves some discussion. Impedance (specific acoustic impedance) is defined as the ratio of the pressure acting on the material to the particle velocity flowing into the material. However, the development inherent in program CHIEF assumes that the positive direction of the velocity is outward from the radiator into the surrounding medium. Hence, to use the velocity designation implicit in CHIEF in the impedance definition, the minus sign is required. *[The authors wish to acknowledge particularly valuable personal communication on this subject with Professor Alan Pierce, Department of Mechanical Engineering, Pennsylvania State University.]*

Equation (A1.3) can be used to eliminate either of the unknowns P_I or V_I from Eq. (A1.2) as a function of the other. It seems more appropriate to eliminate P_I since the opposite choice would entail a division by Z and it is recognized that $Z = 0$ is a value to be used in the subsequent calculations. Accordingly, one may reformulate the matrix equation for unknown surface quantities as

$$\begin{bmatrix} A_{RR} & (-A_{RI}Z - B_{RI}) \\ A_{IR} & (-A_{II}Z - B_{II}) \end{bmatrix} \begin{bmatrix} P_R \\ V_I \end{bmatrix} = \begin{bmatrix} B_{RR} & 0 \\ B_{IR} & 0 \end{bmatrix} \begin{bmatrix} V_R \\ 0 \end{bmatrix}. \quad (A1.4)$$

As this is formally the same as Eq. (A1.2), one may proceed to have the existing routines of CHIEF solve this modified set of equations. Once P_R and V_I are known, P_I is obtained from Eq. (A1.3). The now known surface pressure and velocities are resorted back into their respective array positions, and CHIEF proceeds from this point with the calculation of the pressure at points exterior to the radiator surface in the usual manner.

In this development, the non active portions of the surface of the vibrator are assumed to be coated with a true locally reacting impedance material which creates a boundary condition at those surfaces as described by Eq. (A1.3). This impedance can have a value (real, imaginary, or complex) from zero (perfect pressure release material) to the largest value the computer in question can accept (which approximates a rigid boundary). It should be noted, in particular, that specifying this impedance value to equal the characteristic impedance of the medium does not mean that those portions of the boundary behave as if they were acoustically transparent; i.e., because this boundary condition does not guarantee continuity of both pressure and normal particle velocity at the interface between the medium and the impedance coating, there will be reflections from the boundary even though the impedance value matches the characteristic impedance of the medium, unless the boundary is effectively planar in shape.

A2: Radiation Impedance Matrix

The radiation impedance matrix (Z_{RAD}) relates the forces and velocities on the various subdivisions as follows

$$\underline{F} = [Z_{RAD}] \underline{v} \quad (A2.1)$$

However when part of a radiator, Region R, has a normal velocity v_R while the remaining K surfaces, Region I, are coated with the arbitrary complex locally reacting impedance layer, Eq. (A2.1) can be written as

$$\begin{bmatrix} \underline{F}_R \\ \underline{F}_I \end{bmatrix} = \begin{bmatrix} [Z_{RR}] & [Z_{RI}] \\ [Z_{IR}] & [Z_{II}] \end{bmatrix} \begin{bmatrix} \underline{v}_R \\ \underline{v}_I \end{bmatrix}. \quad (A2.2)$$

The subscripts R and I merely indicate a convenient subdivision of the problem into the two different boundary condition regions.

The radiating force is derived from Eq. (A2.2) as

$$\underline{F}_R = [Z_{RR}]\underline{v}_R + [Z_{RI}]\underline{v}_I \quad (A2.3)$$

In order to determine the radiation impedance matrix for a partially coated radiator, one must write Eq. (A2.3) in the form of Eq. (A2.1). One approach is to write \underline{v}_I as a function of \underline{v}_R . By substituting the equivalent form of \underline{v}_I in Eq. (A2.3), a product of \underline{v}_R and the desired radiation matrix results.

Therefore the first step is to reformulate the velocities of the impedance surfaces \underline{v}_I . Because the individual terms of the matrices are needed, summation notation will be used.

For the impedance surface, the force takes the form

$$F_i = \sum_r Z_{ir} v_r + \sum_p Z_{ip} v_p, \quad (A2.4)$$

where i and p vary from (N - K + 1) to N and r varies from 1 to N - K. Note that v_r is the velocity of the radiating surface and v_i is the velocity of the impedance layer.

With the new modified CHIEF program a complex impedance quantity (Z_i) is specified such that

$$F_i = -Z_i v_i. \quad (A2.5)$$

Setting the right sides of Eqs. (A2.4) and (A2.5) equal to one another, we get

$$-Z_i v_i = \sum_r Z_{ir} v_r + \sum_p Z_{ip} v_p. \quad (A2.6)$$

Upon bringing the term on the left side of Eq. (A2.6) under the summation sign and rearranging, the following equation results

$$\sum_p (-Z_{ip} - \delta_{pi} Z_i) v_p = \sum_r Z_{ir} v_r, \quad (A2.7)$$

where $\delta_{pi} = 1$ if $p = i$ and $\delta_{pi} = 0$ if $p \neq i$. Equation (A2.7) relates the velocities on the impedance surfaces to the velocities of the radiating surfaces and can be rewritten in matrix notation in the following way

$$\left\{ -[Z_{II}] - \begin{bmatrix} Z_{N-K+1}^{\sim} & & 0 \\ & \ddots & \\ 0 & & Z_N^{\sim} \end{bmatrix} \right\} \underline{v}_I = [Z_{IR}] \underline{v}_R, \quad (\text{A2.8})$$

where Z^{\sim} is the prescribed complex impedance; i.e., Z_i of Eq. (A2.5). Equation (A2.8) can be simplified in the form

$$- [\overline{Z_{II}}] \underline{v}_I = [Z_{IR}] \underline{v}_R \quad (\text{A2.9})$$

or

$$\underline{v}_I = -[\overline{Z_{II}}]^{-1} [Z_{IR}] \underline{v}_R. \quad (\text{A2.10})$$

Substituting \underline{v}_I [Eq. (A2.10)] into Eq. (A2.3), we obtain

$$\underline{F}_R = [Z_{RR}] \underline{v}_R - [Z_{RI}] [\overline{Z_{II}}]^{-1} [Z_{IR}] \underline{v}_R \quad (\text{A2.11})$$

or

$$\underline{F}_R = \left\{ [Z_{RR}] - [Z_{RI}] [\overline{Z_{II}}]^{-1} [Z_{IR}] \right\} \underline{v}_R. \quad (\text{A2.12})$$

Equation (A2.12) can be abbreviated as

$$\underline{F}_R = \{Z_{RAD}\} \underline{v}_R, \quad (\text{A2.13})$$

where Z_{RAD} is the desired radiation impedance matrix.

APPENDIX B - CID SCREENS

B1: Cone

The screen shown in Fig. B1.1 gives the geometry description for a conical surface. Most of the screen is self explanatory except for a few items. The cone is rotated about the X3 axis with the point of the cone in the +X3 direction. In order to flip the cone about the X1, X2 plane, the maximum cone height must be negative. The minimum cone height is always set to zero. The cone is located at the (0,0,0) position and can be relocated by changing the local origin.

B2: Impedance Surfaces

Figures B2.1, B2.2, and B2.3 relate to the CHIEF impedance surface modification. Figure B2.1 looks like the CID screen of the previous revision with the exception of the "IMPEDANCE DEFS" entry. When the prompt is placed on this entry, the screen shown in Fig B2.2 appears. The user can pick any surface to be an impedance surface. The letter "I" will appear to the left of each surface description that has been selected. Furthermore, if there are any surfaces after the one selected, they will automatically be impedance surfaces and the letter "I" will also appear to the left of these surfaces. When the "EXIT" entry is chosen in the screen shown in Fig B2.2, the user's screen is updated to the screen shown in Fig B2.3.

The screen shown in Fig. B2.3 appears for every surface that was selected as an impedance surface from the previous screen (Fig. B2.2). The user has the option of selecting one impedance for an entire region or selecting several different impedances. If different impedances are selected for a region, the user has to indicate which subdivision is the first to have an impedance coating. The velocity corresponding to the impedance subdivisions is automatically set to zero in the driver program by the CID program. The CHIEF program calculates the velocities of the impedance surfaces and replaces the zeros in the velocity vector with the calculated values.

REGION 1.

Conical Surface

Change Local Origin (Y/N) Y LOCAL ORIGIN = (0.00E+00 , 0.00E+00 , 10.5E+00)

Global Axis Corresponding to Local X3 Axis	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> X1 X2 X </div>	Direction of Normal	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> X </div>	Outward Inward
--	--	------------------------	--	-------------------

Enter Order of Gaussian Quadrature in U Direction : 8

Enter Order of Gaussian Quadrature in V Direction : 8

Enter Radius of Base : 3.65625

Enter Altitude of untruncated Cone : 3.65625

Minimum Alpha : <u>-0.12566</u>	Minimum Cone Height : <u>0</u>
Maximum Alpha : <u>0.12566</u>	Maximum Cone Height : <u>3.65625</u>

Number of Subdivisions in U Direction : 2

Number of Subdivisions in V Direction : 10

Fig. B1.1. CID screen for conical geometry.

II. Surface Region Inputs

Number of Surface Regions in a Symmetry block : Z

1. SPHERE
2. SIDE1
3. SIDE2
4. BOTTOM
5. FE SIDE 1
6. FE SIDE 2
7. SENSOR

I

Enter Description for each Surface Region (Maximum = 18 letters)

SURFACE GEOMETRY
> IMPEDANCE DEFS
EXIT

Fig. B2.1. CID screen for selecting impedance surfaces option.

II. Surface Region Inputs

Number of Surface Regions in a Symmetry block : Z

1. SPHERE
2. SIDE1
3. SIDE2
4. BOTTOM
5. FE SIDE 1
6. FE SIDE 2
- > I 7. SENSOR

EXIT

Note: Impedance Layer Surface(s) must be last.
Press <RETURN> to define/undefine as an Impedance Layer.

Fig. B2.2. CID screen for selecting which surfaces will have a prescribed impedance.

7 SENSOR

Do you want the same Impedance over the entire surface region (Y/N) **N**

Enter subdivision number where an impedance surface is 1st defined: **1**

Enter Impedance (Real, Imaginary) :

1	(	0.0	,	0.0)
2	(	0.0	,	0.0)
3	(	0.0	,	0.0)
4	(	0.0	,	0.0)
5	(	0.0	,	0.0)
6	(	0.0	,	0.0)
7	(	0.0	,	0.0)
8	(	0.0	,	0.0)
9	(	1.5E6	,	0.0)

ARROW KEYS move up and down columns, **TAB** shifts between columns
RETURN sets to next entry, **PF4** to continue to next surface/exit

Fig. B2.3. CID screen for inputting the complex impedance.

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APPENDIX C - PROGRAM LISTINGS

C1: SURMAT

The subroutine SURMAT generates the matrices A and B of Eq. (A1.4). In addition to the new variable declarations

```
COMMON/COATING/ZCOAT NUMZ
COMPLEX ZCOAT(500),
```

the only other modification is to call the new subroutine MTXSWZS.

```
C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C-----
```

```
SUBROUTINE SURMAT(IREQ,SYMTYP,NBLKS,PMATX,VMATX,MTXDIM)
```

```
C GENERATION OF P AND V SURFACE MATRICES
```

```
C 17 Sep 1990 - impedance coating modifications made by DMB
```

```
PARAMETER (MXSREG=500)
PARAMETER (MXIPS=20)
PARAMETER (MXAUS=510)
PARAMETER (MXGAUS=6.)
PARAMETER (MXQPTS=512)
PARAMETER (MXBLKS=100)
PARAMETER (MXFFP=1.)
PARAMETER (MXNFP=361)
```

```
C
C ***
C PARAMETER (MXFPS=520)
C PARAMETER (MXFPS=MAX(MXARS+MXIPS,MXFFP,MXNFP))
C ***
```

```
COMMON/PMATX(MTXDIM), VMATX(MTXDIM)
```

```
CHARACTER*3 SYMTYP
```

```
COMMON/CONST/RHO,C
COMMON/PRTCOM/NUNPRT,NUNERR
```

```
C 3 Jan 1991 - added temporary logical unit numbers NTEMPVEL, NTEMP1 - NTEMP3.
```

```
COMMON/REALS/NDPMS,PD,MXS,NDVMXS,NODECM,NDVELS,NDSPS,
* NDPMXF,NDVMXF,NDPMXN,NDVMXN,NDPSSP,NDEXPR,NDCOMV,
* NDEMP,NDZROB,NUPATB,NTEMPVEL,NTEMP1,NTEMP2,NTEMP3
COMMON/SVALS/NSREG,NSEQNS(MXSREG),SUL(MXSREG),SUU(MXSREG),
* SVL(MXSREG),SVU(MXSREG),NSU(MXSREG),NSV(MXSREG),
* COS(L,MXSREG),TRNSS(3,MXSREG),IZAX(MXSREG),
* IORDU(MXSREG),IORDV(MXSREG),NCCEQS
COMMON/IPMS/NUMIPS,IPXS(3,MXIPS)
REAL RHO
```

```
COMMON/QPTS/QPS(7,MXQPTS)
COMMON/GAUSNS/MXGAUS(MXGAUS),ROOTU(MXGAUS),ROOTV(MXGAUS),
* TUV(MXGAUS+1,2)
COMMON/PLPIS/PRK1(4,MXFPS),FPC(4,MXFPS)
```

```
COMMON/VECK/VEC1(MXARS),VEC2(MXBLKS),VEC3(MXBLKS),VEC4(MXBLKS),
* VEC5(MXFPS),VEC6(MXFPS)
COMPLEX VEC2,VEC3,VEC4,VEC5,VEC6
DIMENSION FACTRS(MXARS)
EQUIVALENCE (FACTRS(1),VEC1(1))
```

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```

COMMON/PRGVL5/NDIMPV,NUMARS,NUMSFP,NUMFFP,NUMNFP,NWDVEC
COMMON/SURARS/AREAS(MXARS)
COMMON/TAPREC/RECRD(10),IRECRD(30)
COMMON/TAPRC1/ARECRD(10)

C***** impedance coating modifications - 17 Sep 1990 *****
COMMON / COATING / ZCOAT, NUMZ
COMPLEX ZCOAT(MXARS)
C*****

CHARACTER*4 ARECRD

COMPLEX JRHOWP

C
C SURMAT ERROR CHECKS
C

IERR=0

IF (NSREG.GT.MXSREG.OR.NSREG.LE.0) THEN
  IERR=2
  WRITE(NUNERR,1001)NSREG
1001  FORMAT(/,' ERROR IN SURMAT - NSREG=',I6)
  END IF
IF (NBLKS.GT.MXBLKS.OR.NBLKS.LE.0) THEN
  IERR=1
  WRITE(NUNERR,1002)NBLKS
1002  FORMAT(/,' ERROR IN SURMAT - NBLKS=',I6)
  END IF
IF (SYMTYP.NE.'REF'.AND.SYMTYP.NE.'ROT') THEN
  IERR=1
  WRITE(NUNERR,1003)SYMTYP
1003  FORMAT(/,' ERROR IN SURMAT - SYMTYP= ',A3)
  END IF
IF (NUMIPS.GT.MXIPS.OR.NUMIPS.LT.0) THEN
  IERR=1
  WRITE(NUNERR,1004)NUMIPS
1004  FORMAT(/,' ERROR IN SURMAT - NUMIPS=',I6)
  END IF

IF (IERR.EQ.2) STOP

NAR=0
DO 1110 I=1,NSREG
  NAR=NAR+NSU(I)*NSV(I)
  IF (NSEQNS(I).GT.NCCEQS.OR.NSEQNS(I).LE.0) THEN
    IERR=1
    WRITE(NUNERR,1006)I,NSEQNS(I)
1006  FORMAT(/,' ERROR IN SURMAT - REG#,NSEQNS=',2I6)
    END IF
  IZABS=IABS(IZAX(I))
  IF (IZABS.GT.3.OR.IZABS.EQ.0) THEN
    IERR=1
    WRITE(NUNERR,1007)I,IZAX(I)
1007  FORMAT(/,' ERROR IN SURMAT - REG#,IZAX=',2I6)
    END IF
  IF (NSU(I)*NSV(I).LE.0) THEN
    IERR=1
    WRITE(NUNERR,1008)I,NSU(I),NSV(I)
1008  FORMAT(/,' ERROR IN SURMAT - REG#,NSU,NSV=',3I6)
    END IF
  IORDRU=IORDU(I)
  IORDRV=IORDV(I)
  IF (IORDRU.GT.MXGAUS.OR.IORDRV.GT.MXGAUS.OR.IORDRU+IORDRV
    * GT.MXQPTS.OR.IORDRU+IORDRV.LE.0) THEN
    IERR=1
    WRITE(NUNERR,1009)I,IORDRU,IORDRV
1009  FORMAT(/,' ERROR IN SURMAT - REG#,IORDRU,IORDRV=',3I6)
    END IF
1110  CONTINUE

IF (NAR.GT.MXARS.OR.NAR.LE.0) THEN

```

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```

      IERR=1
      WRITE(NUNERR,1111)NAR
1111  FORMAT(/,' ERROR IN SURMAT - #OF AREAS=',I10)
      END IF
      NFP=NAR*NUMIPS
      IF (NFP.GT.WXFPS OR NFP.LE.0) THEN
        IERR=1
        WRITE(NUNERR,1112)NFP
1112  FORMAT(/,' ERROR IN SURMAT - #OF FIELD POINTS=',I10)
      END IF
      MTXT=NAR*NFP
      IF (MTXT.GT.MXDIM OR MTXT.LE.0) THEN
        IERR=1
        WRITE(NUNERR,1113)MTXT
1113  FORMAT(/,' ERROR IN SURMAT - ',I10,' WORDS NEEDED FOR P,V')
      END IF

      IF (IERR.NE.0) STOP

      PI=ACOS(-1.0)
      TWOPI=2.0*PI
      FOURPI=4.0*PI
      ROMEQA=(WOPI*FREQ
      JRHOWP=CMPLX(0.0,ROMEQA*RHO)/FOURPI
      SMALLK=ROMEQA/C
      NDIMPV=MTXDIM

C      COMPUTE QUADRATURE POINTS FOR EACH SURFACE SUBDIVISION(AREA)
C      STORE ON FILE/UNIT NDQPTS
C      COMPUTE FIELD POINT FOR EACH SURFACE AREA AND INTERIOR POINT
C      STORE IN ARRAY FPK1

      CALL IOSUB(NDQPTS,10,QPS,0)
      ISUB=0

      DO 10 I=1,NSREQ
        CALL GAUSS(IORDU(I),ROOTU,WTUV(1,1),WKGAUS)
        WTUV(WXGAUS+1,1)=IORDU(I)
        CALL GAUSS(IORDV(I),ROOTV,WTUV(1,2),WKGAUS)
        WTUV(WXGAUS+1,2)=IORDV(I)

        DELSU=(SUU(I)-SUL(I))/NSU(I)
        DELSV=(SVU(I)-SVL(I))/NSV(I)
        HDELSU=0.5*DELSU
        HDELSV=0.5*DELSV
        FACTI=HDELSU+HDELSV
        UAVE=HDELSU+SUL(I)
        DO 8 J=1,NSU(I)
          VAVE=HDELSV+SVL(I)
        DO 8 K=1,NSV(I)
          ISUB=ISUB+1
          FACTRS(ISUB)=FACTI

        CALL QHGEN(UAVE,VAVE,HDELSU,HDELSV,NSEQNS(I),CCS(1,I),
        *      TRNSS(1,I),IZAX(I),IORDU(I),IORDV(I),ROOTU,ROOTV,QPS)

        CALL IOSUB(NDQPTS,1,WTUV,2*(WXGAUS+1))
        CALL IOSUB(NDQPTS,1,QPS,7*IORDU(I)+IORDV(I))
        CALL CCUNWD(UAVE,VAVE,NSEQNS(I),CCS(1,I),TRNSS(1,I),IZAX(I),
        *      FPK1(1,ISUB),FPBK1(2,ISUB),FPBK1(3,ISUB),D1,D2,D3,DDJ,0)

6      VAVE=VAVE+DELSV
8      UAVE=UAVE+DELSU
10     CONTINUE

      NUMAPS=ISUB
      NUMFPS=ISUB
      NWOVEC=2*NUMAPS

      IF (NUMAPS.NE.0) THEN
        DO 20 I=1,NUMAPS

```


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```

      ISUB=ISUB+1
      DO 15 I=1,3
15      FPK1(I,ISUB)=IPXS(I,J)
20      CONTINUE
      END IF

      NUMFPS=NUMFPS+NUMIPS
      NUMSFP=NUMFPS
      MTXTOT=NUMARS+NUMFPS

C          GENERATION OF SURFACE MATRICES
C          P MATRICES TO FILE/UNIT NDPMXS
C          V MATRICES TO FILE/UNIT NDVMXS

      INTTYP=1

      CALL IOSUB(NDPMXS,10,PMATX,0)
      CALL IOSUB(NDVMXS,10,VMATX,0)

      DO 50 IBLK=1,NBLKS

C          ***** SYMMETRY CONSIDERATIONS *****

      IF (SYMTYP.EQ.'REF') THEN
          CALL FPREFC(IBLK,NUMFPS,INTTYP,FPK1,FPC)
      END IF

      IF (SYMTYP.EQ.'ROT') THEN
          GAMMA=TWOPI/NBLKS
          CALL FPROTC(IBLK,GAMMA,NUMFPS,INTTYP,FPK1,FPC)
      END IF

C          *****

      CALL MATGEN(NUMARS,NUMFPS,FACTRS,INTTYP,WTUV,MXGAUS,
*              NDQPTS,QPC,FPC,SMALLK,PMATX,VMATX)

      IF (IBLK.EQ.1) CALL SLFINT(PMATX,VMATX,NUMARS,NUMFPS,SMALLK,INTTYP,
*              IORDU,IORDV,ROOTU,ROOTV,WTUV,MXGAUS,MXGAUS,
*              NSREG,NSEQNS,CCS,TRNSS,IZAX,SUL,SUU,SVL,SVU,
*              NSU,NSV,FPC,AREAS)

      DO 30 I=1,MTXTOT
          VMATX(I)=VMATX(I)*JRHOWP
30      PMATX(I)=-PMATX(I)/FOURPI

      IF (IBLK.EQ.1) THEN
          DO 40 I=1,NUMARS
              K=(I-1)*NUMFPS+1
40      PMATX(K)=PMATX(K)*0.5
          END IF

C          ***** impedance coating modifications - 17 Sep 1990 *****
          CALL MTXSWSZS(PMATX,VMATX,NUMARS,NUMZ,NUMIPS,ZCOAT)
C          *****

      CALL IOSUB(NDPMXS,1,PMATX,2*MTXTOT)
      CALL IOSUB(NDVMXS,1,VMATX,2*MTXTOT)

50      CONTINUE

      RECRD(1)=FREQ
      RECRD(2)=RHO
      RECRD(3)=C
      IRECRD(1)=NBLKS
      IRECRD(2)=MTXDIM
      IRECRD(3)=NUMARS
      IRECRD(4)=NUMSFP
      ARECRD(1)=SYMTYP

      RETURN
      END

```

C2: SURPRS

The subroutine SURPRS solves matrix equation (A1.4) for unknown quantities. In addition to the new variable declarations

```
COMMON/COATING/ZCOAT,NUMZ
COMPLEX ZCOAT(500),
```

the subroutine SURPRS computes the remaining surface pressures from Eq. (A1.3) and then places the values of the velocities on the impedance-coated regions back into the array VEL (into the last NUMZ positions). The [B] matrix of Eq. (A1.2) is not actually modified to create the indicated right hand side coefficient matrix of Eq. (A1.4); rather the indicated elements B_{RI} and B_{II} are left intact. This can be corrected, however, by inputting zero values into corresponding positions in the velocity vector on the right hand side of Eq. (A1.4). It is critically necessary, therefore, that one initially specify zero values for what would appear to be the velocities on the impedance coated regions.

```
C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C-----
```

```
SUBROUTINE SURPRS(FREQ,SYMTYP,NBLKS,IRHSYM,CMTX,CMTEMP,MTXDIM)
```

```
C  BUILDS RIGHT HAND SIDE,
C  SOLVES EQUATIONS, AND COMBINES SOLUTIONS USING SYMMETRY WEIGHTS
C  TO OBTAIN SURFACE PRESSURES
```

```
C 17 Sep 1990 - impedance coating modifications made by DMB
```

```
C 7 Jan 1990 - bug fix of SURPRS made by PJK
```

```
PARAMETER (MXARS=500)
PARAMETER (MXBLKS=100)
PARAMETER (MXIPS=20)
PARAMETER (MXFFP=361)
PARAMETER (MXNFP=361)
```

```
C  ****
C  PARAMETER (MXFPS=520)
C  PARAMETER (MXFPS=MAX0(MXARS+MXIPS,MXFFP,MXNFP))
C  ***
```

```
COMPLEX CMTX(MTXDIM),CMTEMP(MTXDIM)
```

```
CHARACTER*3 SYMTYP
```

```
COMMON/CONST/RHO,C
COMMON/PRTCOM/NUNPRT,NUNERR
```

```
C 3 Jan 1991 - added temporary logical unit numbers TEMPVEL, TEMP1 - TEMP3.
```

```
COMMON/NDASG/NDQPTS,NDPMXS,NDVMXS,NDDECM,NDVELS,NDSPS,
*      NDPMXF,NDVMXF,NDPMXN,NDVMXN,NDPSSP,NDEXPR,NDCOMV,
*      NDTMP,NDZROB,NDPATB,NTMPVEL,NTMP1,NTMP2,NTMP3
COMMON/PRGVLS/NDIMPV,NUMARS,NUMSFP,NUMFFP,NUMNFP,NWDVEC
COMMON/PLWINP/AINC,THINC,PHIINC,ISCATR
COMMON/BAFFLE/INFRIG
COMMON/MODAL/IMODAL,IUSEFQ
```

```
COMMON/WORK/VEC1(MXARS),VEC2(MXBLKS),VEC3(MXBLKS),VEC4(MXBLKS),
*      VEC5(MXFPS),VEC6(MXFPS)
COMPLEX VEC2,VEC3,VEC4,VEC5,VEC6
COMPLEX R00TUN(MXBLKS),SYMTS(MXBLKS),PRSWTS(MXBLKS)
COMPLEX X(MXFPS),CRHS(MXFPS),CSOLN(MXFPS)
EQUIVALENCE (R00TUN(1),VEC2(1))
```

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```

EQUIVALENCE (SYMNTS(1),VEC3(1))
EQUIVALENCE (PRSWTS(1),VEC4(1))
EQUIVALENCE (X(1),VEC5(1))
EQUIVALENCE (CSOLN(1),VEC6(1))
EQUIVALENCE (CRHS(1),VEC6(1))

COMMON/ODSVEC/TVECT(MXARS),B(MXARS),IPIVTR(MXFPS)
COMPLEX TVECT
COMMON/VELSPS/VEL(MXARS),SP(MXARS)
COMPLEX VEL,SP
COMMON/PDISL/POWER,DIRIND,SRCLVL
COMMON/SURARS/AREAS(MXARS)
COMMON/EXTCOM/EXTPRS(MXFPS),IEXTFG
COMPLEX EXTPRS
COMMON/NBPRTIC/IRHSPT,NARSPT,NPTBLK,FRQPT
COMMON/NBPRTS/SYMTPT
CHARACTER*3 SYMTPT

C***** impedance coating modifications - 17 Sep 1990 *****
COMMON /COATING/ ZCOAT, NUMZ
COMPLEX ZCOAT(MXARS)
C*****

IRHSPT=IRHSYM
FRQPT=FREQ
SYMTPT=SYMTYP

C
C SURPRS ERROR CHECKS
C
IERR=0

IF (NBLKS.GT.MXBLKS.OR.NBLKS.LE.0) THEN
  IERR=1
  WRITE(NUNERR,1002)NBLKS
1002 FORMAT(/,' ERROR :N SURPRS - NBLKS=',I0)
END IF
IF (SYMTYP.NE.'REF'.AND.SYMTYP.NE.'ROT') THEN
  IERR=1
  WRITE(NUNERR,1003)SYMTYP
1003 FORMAT(/,' ERROR IN SURPRS - SYMTYP= ',A3)
END IF

IF (IERR.NE.0) STOP

NWDMTX=2*NUMSFP*NUMARS
NWDVEC=2*NUMARS

CALL IOSUB(NDECM,10,CMTX,0)
CALL IOSUB(NDEMP,10,CSOLN,0)
CALL IOSUB(NDCOMV,10,CMTX,0)

IF(IRHSYM.EQ.0) THEN
  NBSOLN=NBLKS
  DIVSR=NBLKS
ELSE
  NBSOLN=1
  DIVSR=1.0
END IF

DO 100 ISOLN=1,NBSOLN

C ***** SYMMETRY CONSIDERATIONS *****

IF(SYMTYP.EQ.'REF') CALL REFSWT(ISOLN,NBLKS,SYMNTS)

IF(SYMTYP.EQ.'ROT') THEN

IF(ISOLN.EQ.1) THEN
  PI=ACOS(-1.0)

```

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```

      TWOPI=2.0*PI
      ARG=0.0
      DELARG=TWOPI/NBLKS
      DO 10 I=1,NBLKS
      ROOTUN(I)=CMPLX(COS(ARG),SIN(ARG))
10    ARG=ARG+DELARG
      END IF

      CALL ROTSWT(ISOLN,NBLKS,ROOTUN,SYMNTS)

      END IF

C *****

      IF(ISCATR.EQ.0) THEN
      CALL IOSUB(NDCOMV,2,CMTX,NWDMTX)

      CALL COMBMX(X,VEL,NUMARS,1,NDELS,NWDEVC,NBSOLN,SYMNTS)

      CALL MXMLTV(CMTX,X,CRHS,NUMSFP,NUMARS)
      ELSE
      DO 10 I=1,NUMSFP
18    CRHS(I)=(0.0,0.0)
      ENDIF

      IF(TEXTEG.NE.0) THEN
      CALL COMBMX(X,EXTPRS,NUMSFP,1,NDEXPR,2*NUMSFP,NBSOLN,SYMNTS)
      DO 10 I=1,NUMSFP
18    CRHS(I)=CRHS(I)+X(I)
      END IF

      DO 20 I=1,NUMSFP
20    CRHS(I)=CRHS(I)/DIVSR

      IF(INFRIG.EQ.0) THEN
      CALL IOSUB(NDECM,2,CMTX,NWDMTX)
      CALL IOSUB(NDECM,2,TVECT,3*NUMARS*MXFPS)
      CALL ODS(2,CMTX,NUMSFP,NUMARS,TVECT,B,IPIVTR,CRHS,CSOLN)
      ELSE
      DO 25 I=1,NUMARS
25    CSOLN(I)=2.0*CRHS(I)
      END IF

      CALL IOSUB(NDTEMP,1,CSOLN,NWDEVC)

100  CONTINUE

      CALL IOSUB(NDSPS,10,SP,0)
      CALL IOSUB(NDELS,10,VEL,0)

C ***** this rewind added as part of 7 Jan 1991 bug fix *****
      CALL IOSUB(NTMPVEL,10,VEL,0)
C *****

      POWER=0.0

      DO 200 ISOLN=1,NBSOLN

C ***** SYMMETRY CONSIDERATIONS *****

      IF(SYMTYP.EQ.'REF') THEN
      CALL REFSWT(ISOLN,NBLKS,SYMNTS)
      DO 5 I=1,NBLKS
5    PRSWTS(I)=SYMNTS(I)
      ENDIF

      IF(SYMTYP.EQ.'ROT') THEN

```

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```

CALL ROTSWT(ISOLN,NBLKS,ROOTUN,SYMWTS)
PRSWTS(1)=SYMWTS(1)
IF(NBLKS.NE.1) THEN
  DO 12 I=2,NBLKS
12  PRSWTS(I)=SYMWTS(NBLKS-I+2)
  END IF
  END IF

C *****

CALL COMEMX(SP,CSOLN,NUMARS,1,NOTEMP,NWDVEC,NBSOLN,PRSWTS)

IF (ISCATR.EQ.0)CALL IOSUB(NDVELS,2,VEL,NWDVEC)

C***** impedance coating modifications - 17 Sep 1990 *****
DO 401 I = NUMARS - NUMZ + 1, NUMARS
  VEL(I) = SP(I)
  SP(I) = -SP(I) * ZCOAT(I)
401  CONTINUE
C*****

C*****Bug fix of problem with Velocities starts here - 7 Jan 1991

C Modified when the velocity was stored in files for the impedance
C calculations.

  CALL IOSUB(NTMPVEL,1,VEL,NWDVEC)

  CALL IOSUB(NDSPS,1,SP,NWDVEC)
  IF(ISCATR.NE.0)GO TO 200
  DO 150 I=1,NUMARS
150  POWER=POWER+REAL(SP(I)*CONJG(VEL(I)))*AREAS(I)
  CONTINUE

  CALL IOSUB(NTMPVEL,10,VEL,0)
  CALL IOSUB(NDVELS,10,VEL,0)

C  WRITE MATICES CONTAINED IN NTMPVEL TO NDVELS

  DO 225 I=1,NBSOLN
    CALL IOSUB(NTMPVEL,2,VEL,NWDVEC)
    CALL IOSUB(NDVELS,1,VEL,NWDVEC)
225  CONTINUE
***** end of 7 Jan 1991 mods *****

IF(IMODAL.NE.0)THEN
  CALL IOSUB(NDTEMP,10,SP,0)
  DO 300 ISOLN=1,NBSOLN
    CALL IOSUB(NDTEMP,2,SP,NWDVEC)
300  CALL IOSUB(NDSPS,1,SP,NWDVEC)
  ENDIF

IF(IRHSYM.EQ.1)POWER=NBLKS*POWER
POWER=POWER/1000.

IEXTFQ=0

RETURN
END

```

C3: MTXSWZS

The subroutine MTXSWZS creates the modified coefficient matrices of Eq. (A1.4) from those of Eq. (A1.2). Note that this formulation allows for NUMIPS number of interior points, and consequently the matrices A and B in this subroutine are not necessarily square. Further note that the B matrix of Eq. (A1.2) is not modified to create the exact right hand coefficient matrix of Eq. (A1.4). This is legitimate provided one does not input zero values for the corresponding positions in the velocity vector on the right-hand side of Eq. (A1.4). Also note that the impedance-coated regions are always associated with the latter storage positions in matrices A and B and in the arrays SP and VEL regardless of where the regions actually are on the surface of the radiator.

```

C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C MTXSWZS.FOR was added to CHIEF in September 1990 by W. Thompson
C-----

```

```

SUBROUTINE MTXSWZS(A, B, N, NZ, NUMIPS, ZC)

```

```

C*****
C required in CHIEF for impedance coating cases.
C NOTE: matrix B in eqn AP=BV is not modified.
C*****

```

```

      COMPLEX A(N+NUMIPS, N), B(N+NUMIPS, N), ZC(500)

      NN = N + NUMIPS

      DO 20 I = 1, NN
        DO 10 J = N - NZ + 1, N
          A(I, J) = -A(I, J) * ZC(J) - B(I, J)
10        CONTINUE
20      CONTINUE

      RETURN
      END

```

C4: ZRADMI

The subroutine ZRADMI is called from the CHIEF driver and is used to calculate the radiation matrix only when impedance surfaces are present. When impedance surfaces are present, both ZRADMX and ZRADMI are called.

```

C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C-----

```

```

SUBROUTINE ZRADMI(ZMTX, NUMARS)

```

```

C ZRADMI() is a subroutine that corrects the radiation impedance matrix
C when an arbitrary impedance layer exists on the surface.
C
C Subroutines used: MATRIXINV()

      PARAMETER (MXARS = 500)

C impedance layer constants...
      COMPLEX ZCOAT(500)

```

```

COMMON / COATING / ZCOAT, NUMZ

COMPLEX ZRR(MXARS, MXARS)
COMPLEX ZIR(MXARS, MXARS)
COMPLEX ZRI(MXARS, MXARS)
COMPLEX ZII(MXARS, MXARS)
COMPLEX INVZII(MXARS, MXARS)
COMPLEX TEMP2(MXARS, MXARS)
COMPLEX TEMP3(MXARS, MXARS)
REAL TEMP4(MXARS * 2, MXARS * 2)
REAL TEMP5(MXARS * 2, MXARS * 2)
INTEGER ITEMPI(MXARS)

INTEGER IFIRST, ILAST
INTEGER RFIRST, RLAST

COMPLEX ZMTX
DIMENSION ZMTX(NUMARS, NUMARS)

C The radiation impedance matrix is computed assuming there are no
C impedance surfaces. This matrix ZMTX has dimensions NUMARS x NUMARS.
C ZMTX is partitioned into 4 matrices, ZRR, ZRI, ZIR, and ZII whose
C sizes depend upon the number of impedance surfaces.

      RFIRST = 1
      RLAST = NUMARS - NUMZ
      IFIRST = NUMARS - NUMZ + 1
      ILAST = NUMARS

      DO 30 J = RFIRST, RLAST
        DO 10 K = RFIRST, RLAST
          ZRR(K, J) = ZMTX(K, J)
10      CONTINUE
        DO 20 K = IFIRST, ILAST
          ZIR(K - RLAST, J) = ZMTX(K, J)
20      CONTINUE
30      CONTINUE

      DO 60 J = IFIRST, ILAST
        DO 40 K = RFIRST, RLAST
          ZRI(K, J - RLAST) = ZMTX(K, J)
40      CONTINUE
        DO 50 K = IFIRST, ILAST
          ZII(K - RLAST, J - RLAST) = ZMTX(K, J)
50      CONTINUE
60      CONTINUE

C The impedance coatings are added to the diagonal elements of the
C ZII matrix.

      DO 70 J = 1, NUMZ
        ZII(J, J) = ZII(J, J) + ZCOAT(J + RLAST)
70      CONTINUE

C In order to invert the complex matrix ZII, we partitioned it into
C a real matrix, TEMP4, that is 4 times larger as follows:
C
C      +-      Real ZII      -Imaginary ZII      +-
C      |      Real ZII      -Imaginary ZII      |
C      |      Imaginary ZII      Real ZII      |
C      +-      +-
C
C and inverted this larger real matrix.

      DO 90 J = 1, NUMZ
        DO 80 K = 1, NUMZ
          TEMP4(K, J) = REAL(ZII(K, J))
          TEMP4(NUMZ + K, NUMZ + J) = REAL(ZII(K, J))
          TEMP4(NUMZ + K, J) = AIMAG(ZII(K, J))
          TEMP4(K, NUMZ + J) = -AIMAG(ZII(K, J))
80      CONTINUE
90      CONTINUE

```

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```

90  CONTINUE

      CALL MATRIXINV(TEMP4, TEMP5, ITEMP, NUMZ*2, MXARS*2)

C  After inversion, the result is still partitioned in the same way.
C  The real and imaginary parts of the inverse are now recombined into
C  the complex array INVZII.
C
C      +-
C      |  ** Real INVZII **    -Imaginary INVZII  |
C      |  ** Imaginary INVZII **    Real INVZII    |
C      |  +-
C
      DO 110 J = 1, NUMZ
        DO 100 K = 1, NUMZ
          INVZII(K, J) = CMPLX(TEMP5(K, J), TEMP5(NUMZ + K, J))
100    CONTINUE
110    CONTINUE

C  ZRI is multiplied by the inverse of ZII and put into the TEMP2 array.

      DO 140 J = 1, NUMZ
        DO 130 K = RFIRST, RLAST
          TEMP2(K, J) = 0.0
          DO 120 L = 1, NUMZ
            TEMP2(K, J) = TEMP2(K, J) + ZRI(K, L) * INVZII(L, J)
120    CONTINUE
130    CONTINUE
140    CONTINUE

C  Temp2 is multiplied by ZIR and put into the array TEMP3

      DO 170 J = RFIRST, RLAST
        DO 160 K = RFIRST, RLAST
          TEMP3(K, J) = 0.0
          DO 150 L = 1, NUMZ
            TEMP3(K, J) = TEMP3(K, J) + TEMP2(K, L) * ZIR(L, J)
150    CONTINUE
160    CONTINUE
170    CONTINUE

C  ZMTX is now the correct radiation impedance matrix and is passed
C  back to the CHIEF driver. (Note the size of ZMTX is larger than
C  the size actually needed.

      DO 190 J = RFIRST, RLAST
        DO 180 K = RFIRST, RLAST
          ZMTX(K, J) = ZRR(K, J) - TEMP3(K, J)
180    CONTINUE
190    CONTINUE

      RETURN
      END

```

C5: MATRIXINV

The subroutine **MATRIXINV** is called from **ZRADMI**. This subroutine inverts a matrix and calls the subroutine **DECOMP** and **SOLVER**.

```

C-----
C
C  CHIEF Version 3.10 8-FEB-1991
C
C-----

```

SUBROUTINE MATRIXINV(MAT, INV, INDEX, N, S)

C Inverts a matrix (MAT)

C Subroutines used: DECOMP(), SOLVER()

```

INTEGER N      ! defines size of array to be inverted (N x N)
INTEGER S      ! size of storage area (S x S) (may be larger than array)
INTEGER INDEX  ! used in bookkeeping.
REAL  MAT      ! array to be inverted (destroyed when done)
REAL  INV      ! holds inverted array when done.
INTEGER D      ! +1 or -1 depending on even or odd number of row changes

DIMENSION MAT(S, S), INV(S, S), INDEX(S)

DO 20 I = 1, N
  DO 10 J = 1, N
    INV(I, J) = 0.0
  10 CONTINUE
  INV(I, I) = 1.0
20 CONTINUE

CALL DECOMP(MAT, N, S, INDEX, D)

DO 30 J = 1, N
  CALL SOLVER(MAT, N, S, INDEX, INV(1, J))
30 CONTINUE

RETURN
END

```

C6: DECOMP

The subroutine DCOMP performs a matrix decomposition.

```

C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C-----

```

```

SUBROUTINE DECOMP(A, N, NP, INDX, D)

C Matrix Decomposition routine.

PARAMETER (NMAX = 100, TINY = 1.0E - 20)
DIMENSION A(NP, NP), INDX(N), VV(NMAX)

D = 1.0
DO 12 I = 1, N
  AAMAX = 0.0
  DO 11 J = 1, N
    IF (ABS(A(I, J)) .GT. AAMAX) AAMAX = ABS(A(I, J))
  11 CONTINUE
  IF (AAMAX .EQ. 0.0) PAUSE 'Singular matrix.'
  VV(I) = 1.0 / AAMAX
12 CONTINUE

DO 19 J = 1, N
  IF (J .GT. 1) THEN
    DO 14 I = 1, J - 1
      SUM = A(I, J)
      IF (I .GT. 1) THEN
        DO 13 K = 1, I - 1
          SUM = SUM - A(I, K) * A(K, J)
        13 CONTINUE
      A(I, J) = SUM
    14 CONTINUE
  ENDIF
19 CONTINUE
ENDIF

```

```

AAMAX = 0.0
DO 16 I = J, N
  SUM = A(I, J)
  IF (J .GT. 1) THEN
    DO 15 K = 1, J - 1
      SUM = SUM - A(I, K) * A(K, J)
15    CONTINUE
    A(I, J) = SUM
  ENDIF
  DUM = VV(I) * ABS(SUM)
  IF (DUM .GE. AAMAX) THEN
    IMAX = I
    AAMAX = DUM
  ENDIF
16 CONTINUE

  IF (J .NE. IMAX) THEN
    DO 17 K = 1, N
      DUM = A(IMAX, K)
      A(IMAX, K) = A(J, K)
      A(J, K) = DUM
17    CONTINUE
    D = -D
    VV(IMAX) = VV(J)
  ENDIF

  INDX(J) = IMAX

  IF (J .NE. N) THEN
    IF (A(J, J) .EQ. 0.0) A(J, J) = TINY
    DUM = 1.0 / A(J, J)
    DO 18 I = J + 1, N
      A(I, J) = A(I, J) * DUM
18    CONTINUE
  ENDIF

19 CONTINUE

IF (A(N, N) .EQ. 0.0) A(N, N) = TINY

RETURN
END

```

C7: SOLVER

The subroutine solves a matrix equation.

```

C-----
C
C CHIEF Version 3.10 8-FEB-1991
C
C-----

```

SUBROUTINE SOLVER(A, N, NP, INDX, B)

C This routine solves the set of N linear equations $A \cdot X = B$

DIMENSION A(NP, NP), INDX(N), B(N)

```

II = 0
DO 12 I = 1, N
  LL = INDX(I)
  SUM = B(LL)
  B(LL) = B(I)
  IF (II .NE. 0) THEN
    DO 11 J = II, I - 1
      SUM = SUM - A(I, J) * B(J)
11    CONTINUE

```

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```

      ELSE IF (SUM .NE. 0.0) THEN
        II = I
      ENDIF
      B(I) = SUM
12  CONTINUE

      DO 14 I = N, 1, -1
        SUM = B(I)
        IF(I .LT. N) THEN
          DO 13 J = I + 1, N
            SUM = SUM - A(I, J) * B(J)
13          CONTINUE
          ENDIF
          B(I) = SUM / A(I, I)
14  CONTINUE

      RETURN
      END

```

C8: INITCM

```

C-----
C
C CHIEF Version 3.10 8-FEB-1991
C-----

      SUBROUTINE INITCM

      PARAMETER (MXSREG=500)

      COMMON/CONST/RHO,C
      COMMON/PRTCOM/NUNPRT,NINERR

C 3 Jan 1991 - added temporary logical unit numbers NTEMPVEL, NTEMP1 - NTEMP3.

      COMMON/NJASQ/NDQPTS,NDPMXS,NDVMXS,NDDECM,NDVELS,NDSPS,
      * NDPMXF,NDVMXF,NDPMXN,NDVMXN,NDPSSP,NDEXPR,NDCOMV,
      * NDEMP,NDZROB,NDPATB,NTMFVEL,NTEMP1,NTEMP2,NTEMP3
      COMMON/SVALS/NSREG,NSEQNS(MXSREG),SUL(MXSREG),SUJ(MXSREG),
      * SVL(MXSREG),SVU(MXSREG),NSU(MXSREG),NSV(MXSREG),
      * CCS(10,MXSREG),TRNSS(3,MXSREG),IZAX(MXSREG),
      * IORDU(MXSREG),IORDV(MXSREG),NCCEQS
      COMMON/PLWINP/AINC,THTINC,PHIINC,ISCATR
      COMMON/BAFFLE/INFRIG
      COMMON/MODAL/IMODAL,IUSEFQ

      RHO=1000.
      C=1600.

C***** changed NCCEQS to 13 to add cone - 19 Sep 1990 *****
C  NUMBER OF EQUATION SETS IN CCUMID
      NCCEQS=13
C*****

C  UNIT DESIGNATORS FOR MASS STORAGE
      NDQPT=10
      NDPMXS=11
      NDVMXS=12
      NDDECM=13
      NDVELS=14
      NDSPS=15
      NDPMXF=16
      NDVMXF=17
      NDPMXN=18
      NDVMXN=19
      NDPSSP=20
      NDEXPR=21
      NDCOMV=22
      NDEMP=23

```

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NDZROB=24
NDPTR=25

C 3 Jan 1991 - added temporary logical unit numbers TEMPVEL, TEMP1 - TEMP3.

NTMPVEL = 26
NTEMP1 = 27
NTEMP2 = 28
NTEMP3 = 29

C PRINT UNIT DESIGNATORS
NUNPRT=0
NUNERR=0
C PLANE WAVE VALUES
AINC=0.0
ISCATR=0
C INFINITE RIGID BAFFLE VALUE
INERIG=0
C MODAL MATRIX COMPUTATION FLAG
IMODAL=0
IUSEEQ=0

RETURN
END